TRANSACTIONS

OF THE

American Foundrymen's Association

Proceedings of the

Nineteenth Annual Meeting

HELD AT CHICAGO, ILL.

September 7 to 11, 1914

Volume XXIII

Edited by

A. O. BACKERT

SECRETARY

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Arthur E. Howell

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ALFRED E. HOWELL

President, American Foundrymen's Association 1913-1914

American Foundrymen's Association

Summary of the Proceedings of the Nineteenth Annual Meeting, Chicago, Sept. 7 to 11, 1914

The Nineteenth Annual Meeting of the American Foundrymen's Association was held at the La Salle Hotel and the Stock Yards Inn, Chicago, from Sept. 7 to 11, 1914, both inclusive. Monday, Sept. 7, was devoted entirely to registration, the professional sessions commencing Tuesday morning.

First Session—Tuesday, Sept. 8, 10 a. m., La Salle Hotel

President Alfred E. Howell in the chair.

Joint session, American Foundrymen's Association, American Institute of Metals and Associated Foundry Foremen.

The annual address of welcome was made by H. O. Lange, chairman of the general committee representing the Chicago foundrymen. R. A. Bull, senior vice president of the American Foundrymen's Association, responded to the address of welcome.

Brief addresses were also made by Alfred E. Howell, president, American Foundrymen's Association; G. H. Clamer, president, American Institute of Metals; S. V. Blair, president, Associated Foundry Foremen, and A. O. Backert, secretary, American Foundrymen's Association.

The secretary read the following telegram from Dr. Richard Moldenke, ex-secretary of the American Foundrymen's Association:

Watchung, N. J., Sept. 8, 1914.

A. O. BACKERT, SECRETARY, AMERICAN FOUNDRYMEN'S ASSOCIATION, LA SALLE HOTEL, CHICAGO.

Heartiest greetings to the Association. May you have a most profitable meeting as a result of the great list of papers.

RICHARD MOLDENKE.

A motion was passed instructing the secretary to send Dr. Moldenke an appropriate message in reply to his greetings.

The message sent in compliance with this motion is as follows:

Chicago, Sept. 8, 1914.

DR. RICHARD MOLDENKE, WATCHUNG, N. J.

Your hearty greetings and kind wishes were presented at our opening meeting and were received with great applause. The membership regrets your inability to be with us this week. The Association has instructed me to convey to you reciprocal greetings and hearty thanks for your thoughtfulness and deep interest.

AMERICAN FOUNDRYMEN'S ASSOCIATION,
A. O. BACKERT, SECRETARY.

The chairman appointed the following special committees: *Auditing,* T. W. Sheriffs, C. H. Gale and H. Cole Estep; *Revision of Constitution and By-Laws,* W. H. McFadden, chairman; R. A. Bull, O. J. Abell, A. O. Backert and Ben. D. Fuller; *Nominating,* J. S. Seaman, chairman; W. H. McFadden, Thos. D. West, Joseph T. Speer and L. L. Anthes.

M. W. Alexander, General Electric Co., West Lynn, Mass., gave an illustrated address on "Safety in Foundry Operations". He exhibited various types of safety appliances and first aid apparatus for use in foundries.

Following Mr. Alexander's address, the following papers were presented:

"Notes on Safety Organization", by A. W. Gregg and G. F. Kent, Milwaukee.

"Sanitation and Safety First Applied to the Brass Industry", by Fred Moerl, Chicago.

"Progress in the Safety First Movement", by Arthur T. Morey, Granite City, Ill.

"Safety First", by F. W. Reidenbach, Rochester, N. Y.

The meeting adjourned at 1 p. m.

SECOND SESSION—TUESDAY, SEPT. 8, 2 P. M., LA SALLE HOTEL

President Alfred E. Howell in the chair.

This session opened with the presentation of the annual reports of the executive committee and the secretary-treasurer, after which the following papers were read:

"Electric Motors and Controllers for Foundry Operations", by S. H. Libby, New York.

"Safety in Connection with Grinding Wheel Operations", by R. G. Williams, Worcester, Mass.

"Abrasives", by Clarence Hawke.

"A Material for High Grade Casting", by J. E. Johnson, Jr., New York.

"The Second Story Foundry", by G. K. Hooper, New York.

"Economics of Motor Drive", by H. F. Stratton, Cleveland.

"The Selection of Grinding Wheels for the Foundry", by Carl Frederick Dietz, Worcester, Mass.

"Refractories—Their Selection and Use in the Foundry", by Walter H. Kelley, Pittsburgh.

"Safety First—Driving Back the Saloon", by Thomas D. West, Cleveland.

"Molding Sand Tests", by Dr. Richard Moldenke, Watchung, N. J.

"A New Design of Foundry Cupola", by G. R. Brandon, Harvey, Ill.

The report of the Committee on Industrial Education was presented by the chairman, Paul Kreutzpointner, Altoona, Pa.

Lantern slides, showing features of the safety work of the Chicago Surface Lines were presented.

The meeting adjourned at 4:30 p. m.

THIRD SESSION—WEDNESDAY, SEPT. 9, 10 A M.,
STOCK YARDS INN

Joint session, American Foundrymen's Association and American Institute of Metals.

President Alfred E. Howell in the chair.

The following addresses and papers were presented:

"Foundry Cost Keeping", by F. J. Stephenson, Hoosick Falls, N. Y.

"Prevailing Practice in Estimating the Selling Price of Castings", by A. O. Backert, Cleveland.

"Scientific Management in the Foundry", by Frederick A. Parkhurst, Detroit.

"Revision of the A. F. A. Standard Foundry Cost System", by Harrington Emerson and J. K. Mason, New York.

"Elimination of Waste in Bench Molding", by J. C. Pendelton and R. E. Kennedy, Urbana, Ill.

"Industrial Pioneering, or the Establishment of a Foundry in a New Territory", by L. L. Anthes, Toronto.

"The Training of Foremen, Superintendents and Managers of Foundries", by E. A. Johnson, Wentworth Institute, Boston.

"Dangers of Specialization", by Thomas D. West, Cleveland.

The meeting adjourned at 12:30 p. m.

FOURTH SESSION—WEDNESDAY, SEPT. 9, 2 P. M.,
STOCK YARDS INN

On Malleable Iron

President Alfred E. Howell in the chair.

The following papers were read and discussed:

"Calculating Mixtures for Malleable Cast Iron", by Harrold Hemmenway, Moline, Ill.

"Effect of Varying Silicon and Carbon in Malleable Iron Mixtures", by A. L. Pollard, Batavia, N. Y.

"Some Remarks on the Strength and Ductility of Malleable Cast Iron After the Skin has been Removed", by Enrique Touceda, Albany, N. Y.

"Malleable Iron, Its Manufacture, Characteristics and Uses," by J. P. Pero, East St. Louis, Ill.

"Researches in the Annealing Process for Malleable Castings", by Oliver W. Storey, Madison, Wis.

The meeting adjourned at 4:30 p. m.

Fifth Session—Thursday, Sept. 10, 10 a. m., Stock Yards Inn

On Steel

Vice President R. A. Bull in the chair.

The following papers were read and discussed:

"The Electric Furnace in the Steel Foundry", by W. L. Morrison, Welland, Ont.

"Side-Blow Converter Practice", by John Gregson, Milwaukee, Wis.

"Manufacture of Acid Steel for Castings", by A. F. Blackwood, Detroit.

"Notes on the Microstructure of Steel", by Prof. Wm. Campbell, New York City.

"Some Defects in Steel Castings and Remedies for Them", by John Howe Hall, New York.

The report of the committee on Steel Foundry Standards was presented by the chairman, Dudley Shoemaker. It recommended a series of standard nozzles for steel foundry use and was unanimously adopted.

The meeting adjourned at 1 p. m.

Sixth Session—Thursday, Sept. 10, 2 p. m., Stock Yards Inn

On Gray Iron

President Alfred E. Howell in the chair.

The following papers were read and discussed:

"Cast Iron with Unusual Structure", by K. W. Zimmerscheid, Detroit.

"Iron and Its Properties," by Peter F. Blackwood, Detroit.

"Coke Recovered from Cupola Drop", by W. J. Keep, Detroit.

"Green Sand Cores", by James Mulvey, Troy, N. Y.

"Memorandum on the Preparation of Standard Specifications for Cast Iron for International Export Use", by Dr. Richard Moldenke, Watchung, N. J.

Paul Kreutzpointner, Altoona, Pa., presented a report on the Conservation Congress, held in Washington in 1913, which he attended as a delegate from the American Foundrymen's Association.

The meeting adjourned at 4:30 p. m.

SEVENTH SESSION—FRIDAY, SEPT. 11, 10 A. M., LA SALLE HOTEL

President Alfred E. Howell in the chair.

The report of the auditing committee was presented by H. Cole Estep and upon motion was accepted.

The report of the committee on the revision of the constitution and by-laws was presented by O. J. Abell. The principal change which was made provides for associate membership with annual dues of $5 per year, to which persons engaged in foundry work, such as foremen, or firms and corporations having a commercial interest in foundry operations, but not engaged in the production of castings, or employes thereof, are eligible. The provision was also inserted to charge an initiation fee of $10 for active and $5 for associate membership, commencing May 1, 1915. Upon motion, this report was adopted and referred to the membership for letter ballot and was approved. The full text of the revision appears on pages 9 to 15.

A motion was made and carried to instruct the executive committee to have a bond prepared for the treasurer and to pay the premium out of the funds of the Association.

A resolution was passed instructing the secretary to extend the thanks of the Association to Dr. Richard Moldenke in recognition of his valuable services in behalf of the organ-

ization. The full text of the communication sent to Dr. Moldenke is as follows:

Cleveland, O., Oct. 14, 1914.

DR. RICHARD MOLDENKE,
WATCHUNG, N. J.

DEAR DR. MOLDENKE:

At the recent meeting of our Association, held at Chicago, the secretary was instructed to convey to you the unanimous thanks of the American Foundrymen's Association for your magnificent services in behalf of this Society throughout your term of office in the capacity of secretary and treasurer. The motion was offered by Mr. Ben D. Fuller, of the Westinghouse Electric & Mfg. Co., Cleveland, and his remarks were as follows:

> Dr. Moldenke, our past secretary and treasurer, was previously honored by being made an honorary member of this Association, but in view of the close relationship existing for many years gone by and his well-known efforts in behalf of our Society, I think we ought to make a little more marked appreciation, if it is possible to offer this, and I therefore make a motion that we forward to Dr. Moldenke the unanimous thanks of the American Foundrymen's Association for his past services to this Society.

This motion was carried unanimously and the secretary was instructed to convey to you as strongly as possible the expression of good will of all of the members of our organization.

Sincerely yours,

THE AMERICAN FOUNDRYMEN'S ASSOCIATION,
A. O. BACKERT, *Secretary-Treasurer.*

The following resolution was unanimously adopted:

"Resolved, that it is a pleasure for this association to express its sincere thanks to those who in their various ways have contributed to the success of the convention just coming to a close and that the American Foundrymen's Association takes this means of expressing its pleasure for the co-operation of the Foundry & Machine Exhibition Co., the various hotels, the trade and daily press and to others who so ably participated in this most successful meeting.

"Be it further resolved that at this time we also express our appreciation and extend our thanks to those who contributed the papers at the convention and to our officers who have served us faithfully and well."

The report of the nominating committee was unanimously adopted and the officers whose names appear on page V were elected for the ensuing year.

Following the election, President R. A. Bull was conducted to the chair by J. S. Seaman.

Alfred E. Howell and John A. Penton were elected to honorary membership.

A motion was passed empowering the executive committee to negotiate with the Associated Foundry Foremen, with a view toward amalgamation.

The standing committees whose names appear on pages VI and VII were appointed for the ensuing year by the retiring president, Alfred E. Howell.

Annual Banquet, Sept. 10, 1914, 7 p. m., La Salle Hotel

H. O. Lange, Chicago, toastmaster.

Following an introduction by the toastmaster, brief remarks were made by J. S. Seaman and Joseph T. Speer, past presidents of the American Foundrymen's Association.

Addresses were made by Alfred E. Howell, president, American Foundrymen's Association; G. H. Clamer, president Institute of Metals and Dr. James H. Kirkland, chancellor, Vanderbilt University, Nashville, Tenn.

Entertainment Features

An enjoyable entertainment program was provided. A boat ride, which included music and dancing, was tendered the visiting foundrymen on Tuesday evening. The ladies enjoyed a luncheon at Stock Yards Inn on Wednesday and also a banquet at La Salle hotel, Thursday evening. The Chicago Association of Commerce provided a special train which visited points of interest throughout the city on Friday afternoon.

Revision of Constitution and By-Laws

The changes in the constitution and by-laws authorized at the annual meeting, Sept. 11, 1914, and later approved by letter ballot, are indicated below. The old and unaltered paragraphs of the constitution and by-laws are printed in Roman type and the amendments in Italics.

Constitution

ARTICLE I.

Name and Object.

SEC. 1. This Association shall be known as the American Foundrymen's Association.

SEC. 2. The objects of this Association shall be the advancement of the interests of foundry operators, or all who are concerned in the casting of any kind of metal in sand or loam molds, for any purpose; to collect for use of the Association all proper information connected with the foundry business; to exchange experience and encourage uniform customs and actions among foundrymen.

ARTICLE II.

Membership.

SEC. 1. The membership of this Association shall consist of three classes to be called respectively, active, associate, and honorary members.

SEC. 2. Any person, firm or corporation, engaged in the production of castings of any kind, as employer, superintendent, foreman, or chemist, may be elected an active member; and any associate member may become an active member when

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recommended by the Executive Board and approved by a majority vote of the Association at any regular meeting.

CHANGED TO READ:

SEC. 2. *Any firm or corporation engaged in the production of castings of any kind, or any person so engaged as an employer, manager or superintendent, or as assistant to such, together with any others especially qualified may be elected to active membership.*

SEC. 3. Any person whose knowledge or services are valuable toward the objects of this Association may be elected an associate member. Associate members shall have all the rights of active membership except the power to vote.

CHANGED TO READ:

SEC. 3. *Any person who is engaged in foundry work, such as molding foremen, core foremen, pattern foremen, chipping foremen, chemists, etc., or any firm or corporation having a commercial interest in foundry operations, though not engaged in the production of castings, or any officer or employe of such firm or corporation, may be elected to associate membership.*

SEC. 4. Any individual whose knowledge or services, in connection with the objects of this Association, which have made him pre-eminent among his fellows, may be elected an honorary member.

CHANGED TO READ:

SEC. 4. *Any individual whose knowledge or services, in connection with the objects of this Association, have made him pre-eminent among his fellows, may be elected an honorary member.*

SECTIONS ADDED:

SEC. 5. *Election to active and associate membership shall be vested in the Executive Board, members of which should indicate by letter ballot addressed to the Secretary their choice of applicants. Two negative ballots will reject an applicant.*

SEC. 6. *Election to honorary membership shall be by a two-thirds vote of the members present at a regular meeting upon the recommendation of the Executive Board.*

SEC. 7. *In addition to the rights and privileges common to active members, each person so enrolled shall receive gratis*

a bound volume of Transactions of the Association annually issued.

SEC. 8. *Associate members shall have all rights and privileges of active members except the right to receive gratis, the Transactions in bound volume form. Associate members shall receive gratis, pamphlet copies of all pre-printed, original papers read at conventions.*

SEC. 9. *Honorary members will be entitled to all rights and privileges of active and associate members, but shall not be assessed for any dues or payments of any kind.*

ARTICLE III.

SEC. 1. The officers of this Association shall consist of a President, eight Vice-Presidents and a Secretary-Treasurer, who shall, with the Past-Presidents of this Association, form its Executive Board.

The Vice-Presidents shall elect one of their number as Senior Vice-President.

CHANGED TO READ:

SEC. 1. *The officers of this Association shall consist of a President, ten Vice Presidents, one of whom shall be named Senior Vice-President, and a Secretary-Treasurer, who shall, with the Past-Presidents of this Association, form its Executive Board.*

ARTICLE IV.

SEC. 1. There shall be an annual meeting of this Association, the date and location of which shall be fixed by the Executive Board at least three months in advance of the said meeting.

Twenty-five members shall constitute a quorum of the Association.

SEC. 2. Meetings of the Executive Board may be called by the President or by any three members of said Board, and five members shall constitute a quorum.

ARTICLE V.

SEC. 1. This constitution may be amended at any regular meeting of the Association by a two-thirds vote of the members present, provided the Secretary—through letter ballot submitted to all active members within 30 days after adjournment—shall secure in 30 days after the submission of said letter ballot to the members, a ratification of an amendment by a majority of those returning letter ballot, signed by those voting.

By-Laws

Duties of Officers.

SEC. 1. The duties of the President shall be to preside at the meetings of the Association and of the Executive Board, and to perform such other duties as usually devolve upon a presiding officer.

SEC. 2. The Senior Vice-President shall perform the duties of the President when the latter is absent or unable to perform the same, or in case of vacancy in the office of the President.

SEC. 3. The duties of the Secretary shall be to keep a full and accurate record of the proceedings of the Association and Executive Board, to make an annual report at the annual meeting, showing the number of active, associate and honorary members of the Association, the amount of dues collected, and the orders issued on the Treasurer, and he shall perform such other duties as may be assigned to him by the President or Executive Board.

SEC. 4. The duties of the Treasurer shall be to take charge of all funds of the Association, and pay them out only upon the order of the Secretary, countersigned by the President; he shall report at the annual meeting his receipts and disbursements for the year, in detail; he shall give a bond, the amount of which is to be fixed by the Executive Board.

SEC. 5. It shall be the duty of the Executive Board to manage the affairs of the Association to the best of their ability.

Membership.

SEC. 6. All applications for membership shall be made to the Secretary.

SEC. 7. On the first day of each month the Secretary shall mail to each member of the Executive Board a list of applicants for membership. If he shall not receive, by the 15th day of the same month, the written protest of two of the members of the Executive Board to any application, he shall then enroll the said applicants as members of the Association, and notify them at once of their election.

Dues.

SEC. 8. The annual dues for each active or associate member of the Association shall be $10.00, which shall be due and payable annually in the month of July.

CHANGED TO READ:

SEC. 8. *The entrance fee for active members (effective May 1, 1915) shall be $10.00, which must be submitted with the application. Dues for active members shall be $10.00 per annum.*

SEC. 9. No dues or assessments of any kind shall be collected from honorary members.

CHANGED TO READ:

SEC. 9. *The entrance fee for associate members shall be $5.00 (effective May 1, 1915) which must accompany application. Dues for associate members shall be $5.00 per annum.*

SECTIONS ADDED:

SEC. 10. *All dues shall be payable annually on July 1, and those who shall not have paid their annual dues in twelve months shall have their names dropped from the rolls upon notification by the Secretary.*

SEC. 11. *Within 30 days after notification of election, those seeking membership will forward to the Secretary their annual dues or their election will be invalidated and their entrance fee will be forfeited.*

SEC. 12. *The entrance fee shall cover continuous membership only, and those who allow their membership to lapse for twelve months, will be required to again pay the regular entrance fee upon resuming active or associate membership.*

Elections.

SEC. 10. All officers of the Association shall be elected by ballot by the active members of the Association at its annual meeting; a majority vote of those voting being necessary to elect.

Sec. 10 *changed to Sec.* 13.

SEC. 11. All officers of the Association shall hold office for one year from the adjournment of the annual meeting at which they are elected, and until their successors shall have been elected. In the case of a vacancy occurring in any office during the year, the Executive Board shall fill the vacancy for the unexpired term.

Sec. 11 *changed to Sec.* 14.

Publications

SECTION ADDED:

SEC. 15. *The Executive Board shall have power to authorize the publication of papers and data relating to foundry operations and the activities of the Association at any time it may see fit, together with a faithful transcript of all proceedings at its annual conventions, the same to be issued in bound volume form. The Secretary shall be empowered to sell copies of the bound volume of Transactions at* $5.00 *per volume.*

Order of Business.

SEC. 12. The order of business to be observed at annual meetings shall be as follows:

(1) Reading of the minutes of the last meeting.

(2) Announcement by the President of special committees, as follows:

A committee of five to nominate officers for the following year.

A committee of three to audit the accounts of the Secretary-Treasurer.

A committee of five to report on papers to be presented to the Association.

(3) Report of officers and standing committees.
(4) Report of special committees.
(5) Unfinished business.
(6) New business.
(7) Election of officers.

Changed to Sec. 16.

Amendments.

SEC. 13. These by-laws may be amended at any regular meeting of the Association by a two-thirds vote of the members present, provided the Secretary—through letter ballot submitted to all active members within 30 days after adjournment—shall secure, in 30 days after the submission of said letter ballot to the members, a ratification of an amendment by a majority of those returning letter ballot, signed by those voting.

Changed to Sec. 17.

Rules of Order.

SEC. 14. Roberts' Parliamentary Rules of Order shall be recognized as authority by this Association.

Changed to Sec. 18.

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The Registered Attendance

The following members registered their attendance at the annual meeting of the American Foundrymen's Association, held at the La Salle Hotel, Chicago, Sept. 8-11, 1914:

Abell, O. J., *The Iron Age*, Chicago.
Adams, M. J., president, Federal Foundry Supply Co., Cleveland.
Agricola, Otto, president and general manager, Campbell Mfg. Co., Gadsden, Ala.
Ahara, E. H., general superintendent, Dodge Mfg. Co., Mishawaka, Ind.
Alexander, Magnus W., General Electric Co., West Lynn, Mass.
Allen, W. S., secretary, Detroit Steel Castings Co., Detroit.
Alten, George H., owner and manager, Alten's Foundry & Machine Works, Lancaster, O.
Aman, John H., general manager, Monarch Foundry Co., Detroit.
Anderson, E. B., mechanical engineer, T. H. Symington Co., Rochester, N. Y.
Anderson, Nils, president, Debevoise-Anderson Co., 95 Liberty St., New York.
Anthes, L. L., manager, secretary and treasurer, Anthes Foundry, Ltd., Toronto, Canada.
Ayers, E. M., general manager, Ayers Mineral Co., Zanesville, O.

Backert, A. O., editor, *The Foundry*, Cleveland.
Bacon, B. T., Pickands, Brown & Co., Chicago.
Bacon, Chas. C., Ross-Tacony Crucible Co., Tacony, Philadelphia.
Baird, W. E., demonstrator, Robeson Process Co., Pennington, N. J.
Baldwin, R. L., electric furnace representative, United States Steel Corporation, New York.
Barnes, J. A., foundry superintendent, Kewanee Boiler Co., Kewanee, Ill.
Barr, Edward H., assistant superintendent, C., M. & St. P. R. R., Milwaukee.
Barr, Wm. H., president, National Founders' Association, Buffalo.
Bassett, F. P., sales department, Pennsylvania Steel Co., Steelton, Pa.
Bates, Richard, superintendent foundry, American Car & Foundry Co., Berwick, Pa.
Bauer, Fred W., Rogers, Brown & Co., Cincinnati.
Bayerlein, E. C., treasurer, Nordberg Mfg. Co., Milwaukee.
Beck, Samuel J., superintendent, Pusey & Jones Co., Wilmington, Del.
Bennett, T. Ben., foundry superintendent, Maxwells Limited, St. Marys, Ont., Can.
Bentler, O. A., International Harvester Corporation, Akron, O.
Bertie, C. E., salesman, Rogers, Brown & Co., Philadelphia.
Bever, J. J., manager steel foundry department, Otis Steel Co., Cleveland.
Bill, Harry L., foundry superintendent, Dodge Mfg. Co., Mishawaka, Ind.

Billings, C. E., secretary and treasurer, New Haven Sand Blast Co., New Haven, Conn.
Black, L. J., manager, Beaumont Iron Works Co., Beaumont, Texas.
Blackwood, Alex. F. S., vice president, Michigan Steel Castings Co., Detroit.
Block, Wm. A., chairman board of directors, Spuck Iron & Foundry Co., St. Louis.
Blum, Louis, foundry foreman, Enterprise Foundry Co., Detroit.
Booth, Carl H., vice president, Metallurgic Enginering Co., Chicago.
Brandon, G. R., vice president, Whiting Foundry Equipment Co., Harvey, Ill.
Bossinger, Wm. R., superintendent foundry department, Marion Steam Shovel Co., Marion, O.
Bradley, W. P., superintendent foundries, American Bridge Co., Ambridge, Pa.
Branch, P. S., superintendent foundry, P. & R. Railroad, Reading, Pa.
Brough, E. W., foundry superintendent, Sheffield Car Co., Three Rivers, Mich.
Browne, De Courcy, metallurgical engineer, Goldschmidt Thermit Co., New York.
Brownell, H. L., safety inspector, Chicago Surface Lines, Chicago.
Buechele, L. F., foundry manager, American Pin Co., Waterbury, Conn.
Buhr, J. W. S., manager, American Pattern Works, Detroit.
Bull, R. A., production manager, Commonwealth Steel Co., Granite City, Ill.
Bunts, Neal, assistant manager, Pulaski Foundry & Machine Co., Pulaski, Va.
Burson, Peter, foundry foreman, Independent Harvester Co., Plano, Ill.
Burton, J. R., secretary-treasurer, Geneva Foundry & Machine Co., Geneva, Ill.
Butts, C. J., vice president, Jewell Steel & Malleable Co., Buffalo, N. Y.
Busch, John W., foundry foreman, Chapman Valve Co., Indian Orchard, Mass.

Calkins, Loring G., salesman, Rogers, Brown & Co., Chicago.
Cary, J. B., superintendent American Malleables Co., Owosso, Mich.
Chappelka, A. H., superintendent, Chisholm & Moore Mfg. Co., Cleveland.
Chambers, William, salesman, Garden City Sand Co., Chicago.
Chipps, W. C., superintendent, American Brake Shoe & Foundry Co., Mahwah, N. J.
Clamer, G. O., vice president and secretary, Ajax Metal Co., Philadelphia.
Clark, A. L., superintendent of Foundries, American Brake Shoe & Foundry Co., Chicago.
Clark, A. M., N. W. manager, Columbia Steel Co., Portland, Ore.
Clark, R. W., salesman, Rogers, Brown & Co., New York.
Coady, Thomas F., superintendent, Kennedy Foundry Co., Baltimore.
Coehn, John H., superintendent, French & Hecht, Davenport, Ia.
Collins, J. W., superintendent, Aluminum Castings Co., Detroit.

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Cormack, George, superintendent, Independent Harvester Co., Plano, Ill.
Corrigan, R. T., president, Eastern Pattern Works, Detroit.
Cottrell, William, engineer, Benjamin Electric Mfg. Co., Morton Park, Ill.
Cowen, Fred A., plant manager, Michigan Motor Castings Co., Flint, Mich.
Crane, E. A., engineer, International Harvester Corporation, Chicago.
Crawford, Robert, president and general manager, Atlas Foundry Co., Detroit.
Crivel, George F., president, George F. Crivel & Co., Buffalo.
Cronin, James C., industrial board member, State of Pennsylvania, Philadelphia.
Cushing, Geo. H., general superintendent, H. B. Smith Co., Westfield, Mass.
Cutter, E. B., Norton Co., Chicago.

Daly, T. A., foreman, American Blower Co., Detroit.
Darisse, manager, La Compagnie Desjardins, St. Andre, Quebec, Can.
Dean, William J., foundry foreman, Saco-Lowell Shops, Biddeford, Me.
Debevoise, Paul, treasurer, Debevoise-Anderson Co., New York City.
De Wit, Ernest W., foundry superintendent, Platt Iron Works Co., Dayton, O.
Dick, Chas. K., secretary and treasurer, Dick Bros., Inc., Reading, Pa.
Dick, I. H., assistant foreman, Pennsylvania R. R. Shops, Altoona, Pa.
Dickenson, F. T., superintendent, Railways Materials Co., Toledo, O.
Dietz, Carl F., assistant sales manager, Norton Co., Worcester, Mass.
Dietz, C. J., safety inspector, International Harvester Corporation, Chicago.
Dobson, O. C., salesman, Carborundum Co., Pittsburgh.
Downe, H. K., secretary, Novelty Iron Co., Canton, O.
Drought, J. G., sales manager, U. S. Graphite Co., Chicago.
Drozeski, Chas. F., Illinois Malleable Iron Co., Chicago.
Drysdale, Alex. T., Sheffield Cast Iron Pipe & Foundry Co., Sheffield, Ala.
Duckworth, M. E., foundry superintendent, W. H. Knowles Co., Ottawa, Ill.
Dutton, Jno. W., manager, Indiana Foundry Co., Indiana, Pa.
Duvall, J. H., foundry superintendent, Treadwell Eng. Co., Easton, Pa.
Dye, Geo. W., president, Newport Sand Bank Co., Newport, Ky.

Edwards, A. D., president, Woodruff & Edwards Co., Elgin, Ill.
Elliott, Burt, master mechanic, Chattanooga Roofing & Foundry Co., Chattanooga, Tenn.
Ellis, James, J. W. Paxson Co., Philadelphia.
Elverson, J. S., foreman, Lehigh Foundry Co., Fullerton, Pa.
Erb, Fred, factory manager, Lakeside Foundry, Detroit.

Estep, H. Cole, associate editor, *The Foundry*, Cleveland.
Evans, David, president, Chicago Steel Foundries Co., Chicago.
Eyke, Leonard M., superintendent, Terre Haute Malleable & Mfg. Co., Terre Haute, Ind.

Faller, Frederick R., general manager, Sedro-Woolley Iron Works, Sedro-Woolley, Wash.
Fanner, G. J., vice president, W. W. Sly Mfg. Co., Cleveland.
Fassbinder, Henry G., chemist, Minneapolis Steel & Machinery Co., Minneapolis.
Field, H. E., president, Wheeling Mold & Foundry Co., Wheeling, W. Va.
Fitzgerald, Wm. E., manager, Lewis Foundry Co., Toledo, O.
Flagg, Stanley G. 3rd, Stanley G. Flagg & Co., Philadelphia, Pa.
Fletcher, James R., general superintendent, American Hardware Corporation, P. & F. Corbin Div., New Britain, Conn.
Fletscher, C., general superintendent, Werner & Fleiderer Co., Saginaw, Mich.
Foote, Frank I., salesman, Rogers, Brown & Co., Chicago.
Fox, A. K., Benj. Fox's Sons, Inc., 513 W. 34th St., New York.
Frank, Wm. K., vice president, Damascus Bronze Co., Pittsburgh.
Frohman, E. D., vice president, S. Obermayer Co., Pittsburgh.
Fuller, Benj. D., superintendent of foundries, Westinghouse Electric & Mfg. Co., Cleveland.
Fulton, A. M., assistant superintendent, Fort Pitt Malleable Iron Co., Pittsburgh.

Galligan, J. A., Pickands, Brown & Co., Chicago.
Garrard, J. G., superintendent, Northwestern Malleable Iron Co., Milwaukee.
Gearhart, C. W., superintendent, Lebanon Steel Foundry, Lebanon, Pa.
Ghilygreen, Frank G., general superintendent, American Hoist & Derrick Co., St. Paul.
Gibby, Geo. H., treasurer, Gibby Foundry Co., Boston.
Gibson, S. W., general superintendent, Fanner Mfg. Co., Cleveland.
Glen, Hugh, master mechanic, Pittsburgh Plate Glass Co., Crystal City, Mo.
Gordon, F. E., president, Ohio Sand Co., Conneaut, O.
Goss, Leonard H., foundry foreman, O. K. Stove & Range Co., Louisville.
Green, C. H., superintendent, S. Obermayer Co., Chicago.
Greenlee, W. B., secretary, Greenlee Foundry Co., Chicago.
Gregg, A. W., foundry superintendent, Bucyrus Co., South Milwaukee, Wis.
Grell, Carl, foreman, Majestic Co., Huntington, Ind.
Griffith, S., manager of foundries, Fairbanks-Morse Mfg. Co., Beloit, Wis.
Griswold, W. A., superintendent, Gray & Dudley Hardware Co., Nashville, Tenn.
Gross, Robert, sales manager, Maryland Steel Co., Philadelphia.

Growie, W. E., western representative, W. W. Sly Mfg. Co., Chicago.
Grunau, W. F., superintendent of foundry, Bass Foundry Machine Co., Fort Wayne, Ind.

Hagaman, Orville, foreman, Spuck Iron Foundry Co., St. Louis.
Hall, John H., consulting engineer, 2 Rector St., New York.
Hamilton, A. K., director, Treadwell Engineering Co., Chicago.
Hammond, H., secretary and treasurer, Coast Pipe & Foundry Co., Birmingham, Ala.
Hardy, C. A., sales manager, Whiting Foundry Equipment Co., Chicago.
Hare, Arthur, foreman, Kewanee Boiler Co., Kewanee, Ill.
Harrington, R. F., chemist, Hunt-Spiller Mfg. Corporation, Boston.
Hawes, Alex B., salesman, Pickands, Brown & Co., Chicago.
Hawkinson, E., superintendent, George Cutter Co., South Bend, Ind.
Hawke, C. E., engineer, Carborundum Co., Niagara Falls, N. Y.
Hayes, R. W. E., manager, Hayes Pump & Planter Co., Galva, Ill.
Heaney, J. W., secretary, Enterprise Foundry Co., San Francisco.
Hemmenway, Harrold, foundry superintendent, H. W. Cooper Saddlery Hardware Mfg. Co., Moline, Ill.
Herren, E. D., superintendent, American Brake Shoe & Foundry Co., Chattanooga, Tenn.
Hess, H. Lloyd, secretary and treasurer, Lancaster Foundry Co., Lancaster, Pa.
Higinbotham, L. C., superintendent, Dallas Foundry, Dallas, Texas.
Hill, John, Hill-Brunner Foundry Supply Co., Cincinnati.
Hirshheimer, L. C., secretary, La Crosse Plow Co., La Crosse, Wis.
Holmes, H. G., engineer, Novo Engine Co., Lansing, Mich.
Hommel, Wm., general foreman, Spuck Iron & Foundry Co., St. Louis.
Hopkins, D. P., general works manager, United States Cast Iron Pipe & Foundry Co., Burlington, N. J.
Hornsby, H. T., general manager, United Iron Works Co., Springfield, Mo.
Howard, W. Bruce, secretary and treasurer, Atlas Foundry Co., Detroit, Mich.
Howell, Alfred E., superintendent, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
Howes, G. W., superintendent, Estate of P. D. Beckwith, Dowagiac, Mich.
Howes, John W., foundry superintendent, Estate of P. D. Beckwith, Dowagiac, Mich.
Hummell, A. S., chief chemist and metallurgist, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

Jacobs, S. H., general sales manager, Fanner Mfg. Co., Cleveland.
Janssen, W. A., superintendent, Bettendorf Co., Davenport, Iowa.
Jeaunot, W. E., president, West Michigan Steel Foundry Co., Muskegon, Mich.

Jennings, J. L., superintendent, Smith & Watson Iron Works, Portland, Ore.
Johnson, J. E., Jr., consulting engineer and metallurgist, 52 William St., New York.
Johnston, A. J., salesman and chemist, Hickman, Williams & Co., Chicago.
Johnston, S. T., sales manager, S. Obermayer Co., Chicago.
Jones, Gordon E., resident manager, United States Cast Iron Pipe & Foundry Co., Anniston, Ala.

Kanamann, R. H., foreman, American Foundry Mfg. Co., St. Louis.
Keen, E. A., foundry superintendent, Deming Co., Salem, O.
Keith, Robt. R., assistant superintendent, Sheffield Car Co., Three Rivers, Mich.
Kelley, Walter, Harbison-Walker Refractories Co., Pittsburgh.
Kennedy, Patrick J., manager, Baltimore Malleable & Steel Casting Co., Baltimore.
Kennedy, Robert E., foundry instructor, University of Illinois, Urbana, Ill.
Kerrihard, Geo. M., manager, Kerrihard Co., Red Oak, Iowa.
Kerrihard, K. C., Kerrihard Co., Red Oak, Iowa.
Kerrihard, Max E., Kerrihard Co., Red Oak, Iowa.
Keys, A. R., secretary and general manager, Lakeside Foundry, Detroit.
Kimball, Geo. T., auditor, American Hardware Corporation, New Britain, Conn.
Klapheke, Chas. K., secretary and manager, O. K. Stove & Range Co., Louisville.
Klimek, A. J., superintendent, Vermillion Malleable Iron Co., Hoopestown, Ill.
Knight, M. C., factory manager, Lansing Foundry Co., Lansing, Mich.
Knowlton, C. F., superintendent, Westinghouse Electric & Mfg. Co., N. S. Pittsburgh.
Koch, Geo. B., general foreman, Pennsylvania R. R., Altoona, Pa.
Kremer, J. F., manager, J. W. Paxson Co., Philadelphia.
Kreutzberg, E. C., editorial representative, *The Foundry*, New York.
Kreuzpointner, Paul, Altoona, Pa.

La Rue, M., chemist, David Bradley Mfg. Works, Kankakee, Ill.
Lanahan, Frank J., president, Fort Pitt Malleable Iron Co., Pittsburgh, Pa.
Lane, H. M., president, H. M. Lane Co., Detroit.
Lang, R. F., New York.
Lange, H. O., president, Ferguson-Lange Foundry Co., Chicago.
Lankford, A. H., foundry superintendent, Ohio Cutlery Co., Bellevue, O.
Lawson, Raymond, salesman, Lakeside Foundry, Detroit.
Lawton, E. W., secretary and treasurer, C. A. Lawton Co., De Pere, Wis.
Lee, Chas. C., South Bend Foundry Co., South Bend, Ind.

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Lindsay, Andrew H., Jr., foundry foreman, Hunt-Spiller Mfg. Corporation, South Boston, Mass.
Lenz, Arnold, foundry foreman, American Clay Machinery Co., Bucyrus, O.
Lodge, R. L., treasurer, Lodge Mfg. Co., South Pittsburgh, Tenn.
Long, Geo. A. T., Pickands, Brown & Co., Chicago.
Louis, C. E., president, C. E. Louis, Chicago.
Lundgreen, R. E., salesman, Hickman, Williams & Co., Chicago.

McArthur, C. E., superintendent, Seager Engine Works, Lansing, Mich.
McCormick, C. B., general manager, Lansing Foundry Co., Lansing, Mich.
McCormick, J. S., J. S. McCormick Co., Pittsburgh.
McDonnell, P. D., foundry superintendent, Fanner Mfg. Co., Cleveland.
McFadden, W. H., Ponca City, Okla.
McKaig, W. Wallace, mechanical engineer, McKaig Machine, Foundry & Supply Co., Cumberland, Md.
McIntosh, R. S., superintendent, McCord & Co., Chicago.
McLean, Fred M., secretary and treasurer, Marty Foundry Co., Meridian, Miss.
McNamara, Charles, McNamara-Koster Foundry Co., Indianapolis.
McNamara, T. J., proprietor, McNamara-Koster Foundry Co., Indianapolis.
McNamara, Walter, foreman, McNamara-Koster Foundry Co., Indianapolis.
MacDonald, Robt., foundry manager, Samuel L. Moore & Sons Corporation, Elizabeth, N. J.
MacKinnon, R. B., treasurer, Pease Foundry Co., Ltd., Toronto, Canada.
Mahern, Wm. B., assistant manager and treasurer, Berlin Foundry & Machine Co., Berlin, N. H.
Mann, Henry S., Chicago manager, Goldschmidt Thermit Co., Chicago.
Mann, Ira, foundry superintendent, Novo Engine Co., Lansing, Mich.
Mathews, C. D., assistant superintendent, Camden Iron Works, Camden, N. J.
Maxfield, D. E., superintendent, Florence Iron Works, Florence, N. J.
Mears, James C., district manager, Rogers, Brown & Co., St. Louis.
Mercer, John S., foundry superintendent, American Engineering Co., Philadelphia.
Merriman, M. W., general manager, Madison Foundry, Cleveland.
Michaelson, sales department, Pickands, Brown & Co., Chicago.
Miller, W. H., foundry foreman, Deere & Mansur Co., Moline, Ill.
Miller, E. P., general manager, Lennox Furnace Co., Marshalltown, Iowa.
Mills, E. D., chemist, Joyce-Cridland Co., Dayton, O.
Minnich, V. E., vice president and general manager, Sand Mixing Machine Co., 220 Broadway, New York.
Moore, J. A., foundry superintendent, American Blower Co., Detroit.
Morey, Arthur T., manager safety and fellowship, Commonwealth Steel Co., Granite City, Ill.

Morgan, T., eastern representative, W. W. Sly Mfg. Co., New York.
Morrison, W. L., metallurgist, Electric Steel & Metals Co., Welland, Ont.
Mortensen, E. T., patternmaker foreman, Kewanee Boiler Co., Kewanee, Ill.
Mosal, J. A., Mississippi Foundry & Machine Co., Jackson, Miss.
Muntz, G., general manager, Tropenas Converter Co., 50 Church St., New York.
Murphy, A. A., salesman, M. A. Hanna & Co., Cleveland.

Nordholt, J. B., vice president, Toledo Steel Casting Co., Toledo, O.
Nordfeldt, Chas., pattern shop foreman, Fort Pitt Steel Casting Co., McKeesport, Pa.

O'Brien, D. F., president, A. P. Smith Mfg. Co., East Orange, N. J.
O'Connor, A. J., superintendent, Hunt-Spiller Mfg. Corporation, Boston, Mass.
Oberhelman, J. A., proprietor, J. A. Oberhelman Foundry Co., Cincinnati.
Odenkirk, H. T., superintendent, Western Foundry Co., Chicago.
Oliver, A. J., secretary and manager, R. McDougall Co., Galt, Ontario.

Penton, John A., president, Penton Publishing Co., Cleveland.
Perkins, F. N., Arcade Mfg. Co., Freeport, Ill.
Pero, J. H., salesman, Franklin Park Foundry Co., Indian Orchard, Mass.
Pero, J. P., superintendent, Missouri Malleable Iron Co., East St. Louis, Ill.
Pero, J. P., Jr., president and general manager, Franklin Park Foundry Co., Franklin Park, Ill.
Peterson, P. C., foundry superintendent, W. A. Jones Foundry & Machine Co., Chicago.
Pettigrew, James O., superintendent, Pettigrew Foundry Co., Harvey, Ill.
Phillips, H. P., special representative, Fulton Engine Works, Los Angeles, Cal.
Place, J. E., superintendent, National Foundry Co., Erie, Pa.
Potter, D. A., superintendent, Gas Traction Foundry Co., Minneapolis.
Potts, John G., foundry superintendent, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Proseus, C. B., foundry foreman, George Cutter Co., South Bend, Ind.

Querin, T. S., treasurer, Lebanon Steel Foundry, Lebanon, Pa.

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Reichert, A. W., purchasing agent, National Foundry Co., Erie, Pa.
Reilly, E. M., superintendent, foundries, Iron City Sanitary Mfg. Co., Pittsburgh.
Redrup, W. D., general superintendent, Majestic Co., Huntington, Ind.
Robeson, D. S., Robeson Process Co., Pennington, N. J.
Roeller, Lorenzo A., manager, Roeller Foundry Co., Bay City, Mich.
Root, A. B., Jr., machinist engineer, Hunt-Spiller Mfg. Corporation, Boston, Mass.
Root, P. H., vice president, Root-Heath Mfg. Co., Plymouth, O.
Rothe, Jos. F., president, Joseph F. Rothe Foundry Co., Green Bay, Wis.
Ryan, T. J., demonstrator, Robeson Process Co., Chicago, Ill.

Seaman, Jos. T., president, Seaman-Sleeth Co., Pittsburgh.
Seasholtz, J. M., superintendent, Reading Stove Works, Reading, Pa.
Schmidt, J. P., superintendent, pattern shop and foundry, Busch-Sulzer Diesel Engine Co., St. Louis.
Schneider, E. L., superintendent, Lennox Furnace Co., Marshalltown, Ia.
Schoemaker, Dudley, works manager, American Steel Foundries, Indiana Harbor, Ind.
Schoenheiter, H. K., superintendent, American Brake Shoe & Foundry Co., Mahwah, N. J.
Schum, E. M., foundry superintendent, Wm. Wharton, Jr., & Co., Inc., Philadelphia.
Scott, Wm., general superintendent, American Hardware Corporation, R. & E. Div., New Britain, Conn.
Shaw, A., vice president and general manager, West Michigan Steel Foundry Co., Muskegon, Mich.
Shaw, J. M., superintendent, Mosher Mfg. Co., Dallas, Texas.
Sheriffs, T. W., vice president and manager, Sheriffs Mfg. Co., Milwaukee.
Sherwin, John, president, Chicago Hardware Foundry Co., North Chicago, Ill.
Shuchman, B. F., superintendent, Homestead Valve & Mfg. Co., Homestead, Pa.
Skarin, H. J., foreman, Geneva Foundry & Machine Co., Geneva, Ill.
Sklovsky, Max, chief engineer, Deere & Co., Moline, Ill.
Sleeth, S. D., superintendent, Westinghouse Air Brake Co., Wilmerding, Pa.
Sly, W. C., president, W. W. Sly Mfg. Co., Cleveland.
Smith, G. O., superintendent, Detroit Steel Casting Co., Detroit.
Smith, E. W., general foundry foreman, Crane Co., Chicago.
Smith, I. R., secretary and treasurer, Sterling Wheelbarrow Co., Milwaukee.
Snyder, F. T., engineer, Metallurgic Engineering Co., Chicago.
Sonne, A. P., office manager, Rogers, Brown & Co., Chicago.
Sowers, D. W., president, Sowers Mfg. Co., Buffalo.
Speer, Jos. T., president, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

Sperry, G. R., president, Geneva Foundry & Machine Co., Batavia, Ill.
Stephenson, F. J., cost expert, National Association of Stove Manufacturers, Hoosick Falls, N. Y.
Stoddard, J. D., treasurer, Detroit Testing Laboratory, Detroit.
Stoneham, S., superintendent, Michigan Steel Castings, Detroit.
Storey, Henry B., salesman, Tilghman-Brooksbank Sand Blast Co., Philadelphia.
Street, Guy E., molder foreman, Michigan Motor Castings Co., Flint, Mich.
Strater, H. B., superintendent, Buhl Malleable Co., Detroit.
Swan, Harry B., assistant superintendent of foundries, Cadillac Motor Car Co., Detroit.
Swasey, H. M., E. D. Jones & Sons Co., Pittsfield, Mass.

Taggart, E. M., J. W. Paxson Co., Philadelphia.
Taylor, Harry T., Frederic B. Stevens, Detroit.
Taylor, J. H., superintendent, Western Steel & Iron Works, Winnipeg, Can.
Taylor, W. H., Ross-Tacony Crucible Co., Railway Exchange, Chicago.
Teiber, Joseph M., superintendent, American Foundry Mfg. Co., St. Louis.
Thompson, A. M., foundry superintendent, H. W. Caldwell & Son Co., Chicago, Ill.
Tolmie, Robt. C., works manager, Lobdell Car Wheel Co., Wilmington, Del.
Touceda, Enrique, metallurgical engineer, Albany, N. Y.

Wait, George E., foreman, Ober Mfg. Co., Chagrin Falls, O.
Walton, George, secretary and treasurer, Madison Foundry Co., Chicago.
Walton, Jos., Madison Foundry Co., Chicago.
Wallace, A. L., engineer, Whiting Foundry Equipment Co., Harvey, Ill.
Way, L. A., superintendent, Duquesne Steel Foundry Co., Coraopolis, Pa.
Weaver, Adrian B., Rogers, Brown & Co., Chicago.
Webb, W. C., U. S. Graphite Co., Chicago.
Webster, Glenn, secretary, Geneva Metal Wheel Co., Geneva, O.
Weihrauch, Gustav, superintendent, Toledo Steel Castings Co., Toledo, O.
Weir, S. E., works manager, American Blower Co., Detroit.
Welch, Florence M., E. J. Welch Foundry Co., Chicago.
Welch, E. C., general foreman, Norfolk & Western R. R., Roanoke, Va.
West, Thos. D., managing director, West Steel Casting Co., Cleveland.
White, William S., proprietor and manager, J. S. white Co., Pawtucket, R. I.
Whitmarsh, Edwin B., Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

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Whiting, B. H., assistant superintendent, Whiting Foundry Equipment Co., Harvey, Ill.
Williams, R. G., safety engineer, Norton Co., Worcester, Mass.
Wilson, H. M., president, Taylor-Wilson Mfg. Co., Pittsburgh.
Woodison, E. J., president, E. J. Woodison Co., Detroit.
Woodside, Arthur M., superintendent, Woodside Bros., Port Arthur, Ont., Can.
Wyant, T. A. secretary and treasurer, Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.

Yergason, H. B. B., advertising manager, Rogers, Brown & Co., Cincinnati.

Zatel, F. W., assistant superintendent, Kewanee Boiler Co., Kewanee, Ill.

Annual Report of Secretary-Treasurer

To the President and Members of the American Foundrymen's Association:

Both in prestige and membership the American Foundrymen's Association made big gains during the last year and with a return of trade conditions to normal it is believed that an enrollment of 1,000 can be attained before our next annual meeting. On Aug. 1, the membership reached a total of 760, the high point in the history of the Association, and a gain of 45 since July 1, 1913. During the year, 14 members were dropped for non-payment of dues and 12 resigned. An active campaign for new members was conducted during the months of June and July, the results of which were particularly gratifying.

Your Secretary-Treasurer assumed the duties of his office April 1, 1914, when the records, bound volumes, etc., were turned over to him by the retiring secretary-treasurer, Dr. Richard Moldenke. The records of the office were so well maintained and so complete, that no difficulty was experienced in carrying on the work, and therefore no break occurred in the conduct of the affairs of your Association while the transfer was being made. Furthermore, Dr. Moldenke co-operated with your secretary-treasurer in every possible way and his unselfish spirit of helpfulness greatly lightened the burdens of the secretarial office.

For the first time in the history of your organization, the secretary was relieved of the tremendous amount of work entailed in securing papers and arranging for the program for the annual meeting. At our last convention, former President H. D. Miles appointed a committee on papers and program, and the excellent manner in which the work has been done is reflected in the long list of magnificent papers and addresses that are to be presented for your consideration. In this work J. J. Wilson, of Detroit, chairman, was ably assisted by H. B. Swan, and to promote the interest of some of the world's leading metallurgists in your society, Mr. Swan

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visited Albany, Boston and New York in his quest for papers from scientists of world-wide fame. This first experiment with a committee on papers certainly warrants its continuation and the gratifying results obtained merit widening the scope of the committee work of your organization.

The affairs of the world's leading technical societies largely are conducted by committees and the number of committees of the American Foundrymen's Association should be greatly increased. In the appointment of members to carry on such work, care should be exercised to localize them as far as possible, thereby reducing traveling and incidental expenses.

Owing to the fact that the duties of your former treasurer were terminated on March 31, 1914, financial statements are shown covering the period from July 1, 1913, to March 31, 1914. and from April 1, 1914, to June 30, 1914. The combined statement shows total receipts of $6,391.14 and disbursements of $6,315.31, leaving a balance in the treasury on July 1, of $75.83. The cost of the *Transactions* was $3,371.05, and it is believed that this expenditure will be greatly increased in the publication of Volume XXIII, as there is every indication that this will contain approximately 800 pages. It, therefore, is absolutely essential that the revenue of the Association be greatly increased and the only method by which this can be accomplished at present is by the enrollment of new members.

The accompanying chart graphically shows the fluctuations in the membership of your society and a table also is herewith presented showing the growth of the organization from year to year. The Thousand-Member Club, inaugurated several months ago, should be productive of excellent results and every foundryman affiliated with your Association should appoint himself a committee of one with instructions to obtain at least one application. The society never has been able to accumulate a safe balance in its treasury and every effort should be directed to achieve this end. One method by which this may be accomplished, in part, would be from the proceeds of an initiation fee, and this to some extent would reduce the number of resignations.

Respectfully submitted,

A. O. BACKERT, *Secretary-Treasurer.*

TREASURER'S REPORT

July 1, 1913, to July 1, 1914

Receipts

Balance July 1, 1913	$ 90.83
Annual Dues, Subscriptions, etc	5,550.31
Contribution, Foundry & Machine Exhibition Co	750.00
	$6,391.14

Disbursements

Transactions	$ 3,371.05	
Printing	212.94	
Postage	564.00	
Salaries	1,200.00	
Stenographic Work	75.00	
Sundries	41.83	
Traveling Expense (Com. Meetings, Etc.)	109.55	
Convention Expense	419.64	
Foundry & Machine Exhibition Co.'s contribution to the American Institute of Metals	200.00	
Foundry & Machine Exhibition Co.'s contribution to the Associated Foundry Foremen	100.00	
Accident Committee	21.30	
		$6,315.31
Balance		$ 75.83

Report of the Former Treasurer, Dr. Richard Moldenke

July 1, 1913, to March 31, 1914

Receipts

Balance, July 1, 1913	$ 90.83	
Annual dues, subscriptions, etc	5,360.01	$5,450.84

Disbursements

Transactions	$3,371.05	
Convention expenses	334.44	
Printing	65.26	
Postage	424.00	
Salaries	900.00	
Sundries	37.28	
Accident Committee	21.30	$5,153.33
Balance		$ 297.51

Transmitted to A. O. Backert:—	
March 24, 1914	$250.00
May 12, 1914	47.51
	$297.51

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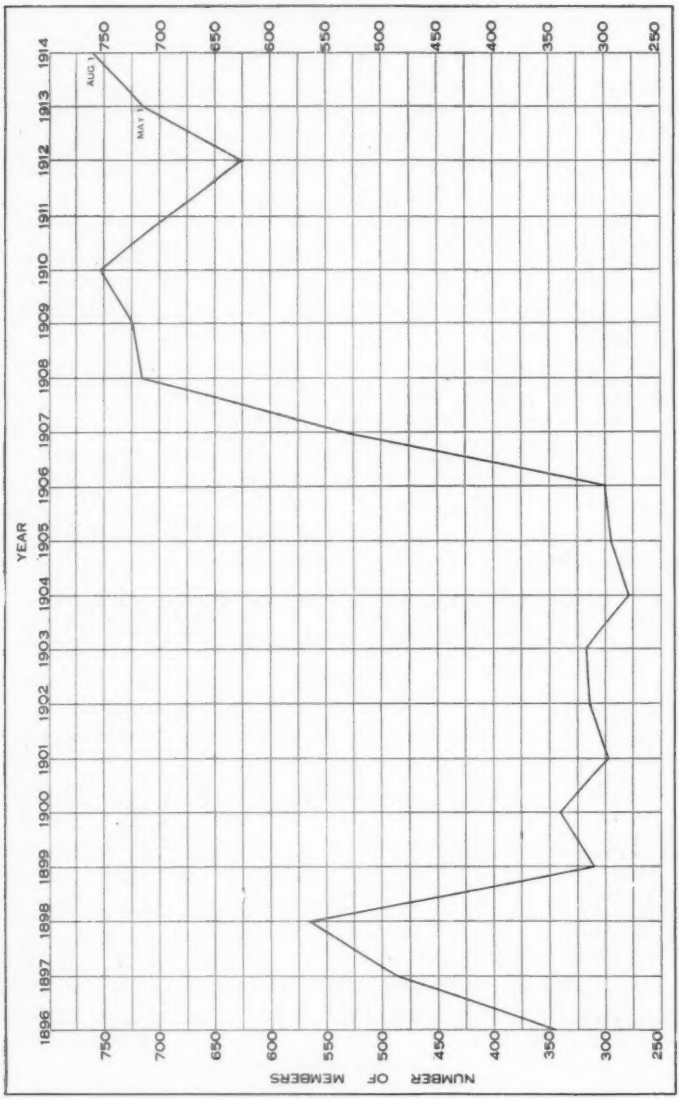

CHART SHOWING GROWTH IN MEMBERSHIP OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION

Partial Financial Statement of the Treasurer

April 1, 1914, to June 30, 1914

Receipts

April—balance forwarded by Dr. Moldenke	$ 250.00
April 4, contribution, Foundry & Machine Exhibition Co.	750.00
May 12, final balance forwarded by Dr. Moldenke	47.51
Dues, subscriptions, etc	190.30
	$1,237.81

Disbursements

Printing	$ 147.68	
Postage	140.00	
Salaries	300.00	
Stenographic work	75.00	
Sundries	4.55	
Traveling expense (com. meetings, etc.)	109.55	
Convention expense (Papers Committee)	85.20	
Foundry & Machine Exhibition Co.'s contribution to American Institute of Metals	200.00	
Foundry & Machine Exhibition Co.'s contribution to Associated Foundry Foremen	100.00	
	$1,161.98	$1.161.98
Balance		$ 75.83

Book balance in bank		$233.83
Checks not in No. 19	$ 25.00	
Checks not in No. 20	100.00	
Checks not in No. 21	33.00	
		$158.00
Actual bank balance June 30		$ 75.83

Membership of the American Foundrymen's Association.

Convention number.	Year.	Number of members.	Place of meeting.
1	1896	345 delegates	Philadelphia
2	1897	486	Detroit
3	1898	566	Cincinnati
4	1899	310	Pittsburgh
5	1900	341	Chicago
6	1901	297	Buffalo
7	1902	314	Boston
8	1903	317	Milwaukee
9	1904	278	Indianapolis
10	1905	294	New York
11	1906	300	Cleveland
12	1907	532	Philadelphia
13	1908	715	Toronto
14	1909	724	Cincinnati
15	1910	753	Detroit
16	1911	692	Pittsburgh
17	1912	626	Buffalo
18	May 1, 1913	715	Chicago
19	Aug. 1, 1914	760	Chicago

Annual Report of the Executive Committee

Minutes of the Joint Foundry Convention Committee Meeting Held at St. Louis, Nov. 10, 1913

After an informal discussion of the convention situation for 1914, by the joint committee which convened in Cincinnati, Sunday, Nov. 9, 1913, it was decided to adjourn the meeting to St. Louis for a definite understanding. Accordingly, on Nov. 10, 1913, at the Planters hotel, St. Louis, the committee convened with Alfred E. Howell, president of the American Foundrymen's Association; F. N. Perkins, president of the Foundry & Machine Exhibition Co.; C. E. Hoyt, secretary, Foundry & Machine Exhibition Co., and R. A. Bull, senior vice president of the American Foundrymen's Association, in attendance. Mr. Howell was asked to take the chair and act as permanent chairman of the joint committee; he appointed Mr. Bull secretary.

Mr. Howell read letters from G. H. Clamer, president, and W. M. Corse, secretary, of the American Institute of Metals, expressing their approval for their society of the idea of holding the convention in Chicago simultaneously with the exhibit about the latter part of August, 1914, such letters being of the same nature as proxies. Mr. Bull advised the committee that Robert B. Thomson, secretary, stated to him that the Associated Foundry Foremen stipulate in their by-laws that they will follow the policies and example of the A. F. A. so far as conventions are concerned. Dr. Richard Moldenke's views as opposed to the convention being held in 1914 in Chicago were briefly made known to the joint committee by Mr. Howell and Mr. Bull. Mr. Hoyt, for the Exhibition company, submitted a formal letter addressed to Mr. Howell as president of the A. F. A., guaranteeing positively that the F. & M. E. Co., if Chicago shall be selected for the 1914 convention, will provide amply for the entertainment of the convention visitors, apparently leaving nothing to be desired in

this connection and relieving the local foundry concerns of Chicago from any financial burden.

Mr. Perkins and Mr. Howell stated that suitable hotel accommodations could not be furnished for the latter part of August in Chicago, because of other convention dates conflicting and reported the most suitable time from that standpoint would be between Sept. 1 and 15.

After a thorough discussion, Mr. Howell, on behalf of Mr. Corse, whose proxy Mr. Howell held, offered the following resolution, seconded by Mr. Bull, which was unanimously adopted:

"Whereas, On Nov. 9, 1913, a committee representing the American Foundrymen's Association, American Institute of Metals, Associated Foundry Foremen and the Foundry & Machine Exhibition Co., met in Cincinnati for the purpose of conferring regarding the date and location of the next Foundrymen's convention and exhibit, and this meeting adjourned from Cincinnati to St. Louis, and

"Whereas, at a meeting held this Nov. 10th, in St. Louis, it was unanimously decided by those present in person and by proxy, that the convention and exhibit should be held simultaneously, therefore, be it

"Resolved, That the 1914 meeting of the allied associations and the Exhibition company be held in Chicago during the week of Sept. 7 to 12, and that at a meeting to be held Jan. 17, 1914, at the Hotel La Salle, Chicago, with resident foundrymen, the details and committee work shall be arranged, and that, regarding the meeting for 1915, so far as it is possible for those present to say, this will be held in the east during June, with a view of holding an International Foundrymen's Congress and Exhibit.

Alfred E. Howell, president, A. F. A.
R. A. Bull, vice president, A. F. A.
F. N. Perkins, president, F. & M. E. Co.
C. E. Hoyt, secretary, F. & M. E. Co.

Several copies of the resolution were prepared, each having the original signatures of Messrs. Howell, Bull, Perkins and Hoyt.

Mr. Howell, chairman of the joint committee, instructed Mr. Bull, as secretary, to immediately notify the technical press as per the following announcement:

We are pleased to announce that the conventions of the American Foundrymen's Association, the American Institute of Metals and the Associated Foundry Foremen will be held simultaneously with the exhibit of the Foundry & Machine Exhibition Co., in Chicago, from Sept. 7 to 12 inclusive, 1914.

American Foundrymen's Association,
American Institute of Metals,
Associated Foundry Foremen,
Foundry & Machine Exhibition Co.

Headquarters for the convention were discussed and the Hotel La Salle was selected on motion of Mr. Bull, seconded by Mr. Howell for G. H. Clamer, as being most satisfactory for taking care of the members of the American Foundrymen's Association, and the American Institute of Metals. It was understood, however, that no announcement of the selection of the Hotel La Salle should be made until Mr. Stevens for the hotel company confirms formally his verbal proposition, as made to Mr. Hoyt, concerning certain entertainment features.

A number of questions were discussed informally as relating to the 1914 convention, including the places in Chicago best adapted for holding the sessions, and it was thought best to leave these questions for general discussion at Chicago, Jan. 17, 1914.

Mr. Howell stated that Dr. Richard Moldenke, W. M. Corse and Robert B. Thomson were to be immediately advised of the action taken.

The representatives present for the Exhibition company reported that their company desired to meet alternately east and west in the future, and they on investigation had found that splendid facilities will be available in Philadelphia for 1915, suitable in all respects for the International Foundry Congress proposed to be held in the east.

There being no further business, the meeting adjourned to convene again in Chicago on the morning of Jan. 17, 1914, at the Hotel La Salle, or at the call of the chairman of the joint committee.

R. A. BULL,
Secretary Joint Foundry Convention Committee.
ALFRED E. HOWELL, Chairman.

Minutes of the American Foundrymen's Association Executive Committee Meeting Held at the Hotel La Salle, Chicago, Jan 17, 1914

President Alfred E. Howell called the meeting to order at 10:15 a. m. The following members of the committee were present:

Alfred E. Howell, Joseph T. Speer, W. H. McFadden, L. L. Anthes, J. J. Wilson, T. W. Sheriffs and R. A. Bull.

Upon motion by Major Speer, Mr. Bull was elected acting secretary, Dr. Richard Moldenke being absent.

Mr. Howell submitted a verbal report on behalf of the convention sub-committee to the effect that said committee had met in St. Louis, Nov. 10, 1913, adjourning from Cincinnati on Nov. 9, with Messrs. Howell, Bull, Perkins and Hoyt in attendance, and Mr. Howell holding proxies of Messrs. Clamer and Corse. The decision of the committee was that the 1914 meeting of the allied associations and the Exhibition company be held in Chicago during the week of Sept. 7 to 12, and that at a joint conference to be held Jan. 17, 1914, at the Hotel La Salle, Chicago, with resident foundrymen, the details and committee work shall be arranged, and that regarding the meeting for 1915, if possible that should be held in June in the east, with a view of holding an International Foundrymen's Congress and Exhibit. Mr. Bull as secretary of the joint foundry convention committee, by instructions from Mr. Howell, permanent chairman of the joint committee, notified the technical press under the names of the four organizations of the time and place for the 1914 meeting. Chairman Howell further advised that the Hotel La Salle had been made headquarters for the American Foundrymen's Association and the American Institute of Metals.

Mr. Bull read President Howell's letter, dated Oct. 20, 1913, to Dr. Richard Moldenke; Dr. Moldenke's reply to Mr. Howell, dated Oct. 28; Dr. Moldenke's letter, dated Oct. 27, to Mr. Bull, and Mr. Bull's reply of Nov. 4, to Dr. Moldenke, all with reference to the time and place for holding the 1914 convention of the American Foundrymen's Association. A general discussion followed. Mr. Wilson stated that the Detroit Foundrymen's Association had passed resolutions with reference to this matter at a recent meeting, and that he had a copy of the same, it having been left to his discretion as to whether or not they should be read at the present meeting. Mr. Howell suggested it would be proper to read them in full and accordingly Mr. Wilson made them known to the members present, also Mr. Horn's letter to him transmitting the resolutions. Mr. Wilson advised further that

the basis of the resolutions was a motion which carried at the Detroit meeting presented by a supply man.

After a general discussion, Mr. Wilson suggested that no action be taken upon the resolutions other than to file the same and this was concurred in without formal motion.

All present participated in a general discussion concerning the decision made by the convention sub-committee regarding the 1914 convention, following which motion was made by Mr. Sheriffs, seconded by Mr. Wilson, that the action of the convention sub-committee be ratified. The motion carried.

Upon motion by Mr. Bull, the meeting was adjourned to convene in the afternoon, following a joint session of the various organizations interested in the 1914 convention.

After adjournment of the joint conference at 5:30 p. m., the Executive Committee was called to order by President Howell with all present,. except Mr. McFadden, who had participated in the morning session.

Dr. Moldenke's resignation as secretary-treasurer, dated Dec. 23, 1913, was read by Mr. Bull, and upon a free discussion, including the reading by Mr. Wilson of a portion of Dr. Moldenke's letter to him indicating Dr. Moldenke's willingness to continue the editorial work of the association, it was moved by Mr. Sheriffs and seconded by Mr. Wilson that the resignation be accepted. The motion carried.

Sensing Dr. Moldenke's attitude from his letter to Mr. Wilson and in the belief that Dr. Moldenke would be glad to perform the duties which would properly belong to a technical secretary, Mr. Anthes, supported by Mr. Wilson, moved that the position of Editorial and Foreign Secretary be created, salary to date from acceptance of said position, at $900 per annum. Upon affirmative vote it was so ordered. Mr. Bull then moved that Dr. Richard Moldenke be offered the position of Editorial and Foreign Secretary. The motion was seconded by Major Speer and carried.

President Howell was then empowered by affirmative vote, on motion presented by Mr. Bull, seconded by Mr. Wilson, to select an Acting Secretary-Treasurer to perform the duties

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of a business or commercial nature at a salary of $900 per year, salary to date from acceptance.

There being no further business, Mr. Sheriffs moved an adjournment to convene at the call of the president. The motion carried.

All motions here recorded passed without dissent.

R. A. BULL,
Acting Secretary, Executive Committee A. F. A.

Approved:
ALFRED E. HOWELL, Chairman.

Minutes of Joint Conference of Officers of A. F. A., A. I. M., A. F. F., F. & M. E. Co., and Representative Chicago Foundrymen, Held at Hotel La Salle, Chicago, Jan. 17, 1914.

The meeting was called to order at 2:30 p. m. by Chairman Alfred E. Howell, following a luncheon at which, informally, several of those present made felicitous remarks concerning the spirit of co-operation which is destined to make the 1914 Foundrymen's Convention apparently all that could be desired.

A list of those in attendance follows:

L. L. Anthes, S. V. Blair, R. S. Buch, R. A. Bull, C. B. Carter, Wm. Chambers, G. H. Clamer, W. M. Corse, David Evans, T. S. Hammond, Alfred E. Howell, C. E. Hoyt, S. T. Johnston, J. S. McCormick, W. H. McFadden, F. N. Perkins, Geo. R. Rayner, T. W. Sheriffs, Jos. T. Speer, Robt. B. Thomson and Joseph J. Wilson.

Minutes of the meeting of the Joint Foundry Convention Committee, held in St. Louis, Nov. 10, 1913, were read by Mr. Bull, secretary of the joint committee, and approved.

A letter dated Nov. 6, 1913, from Secretary Hoyt of the F. & M. E. Co., to President Howell of the A. F. A., bearing upon a guarantee fund for entertainment features, was read by Mr. Bull and generally discussed. A motion made by Oliver J. Abell provided that the entertainment features consist of two banquets, buffet luncheons, a theater party and one luncheon for the ladies. Mr. Abell's motion was withdrawn

by consent and for it was substituted a motion by Mr. McFadden that we adopt in general the plan of entertainment suggested in Secretary Hoyt's letter of Nov. 6, subject to any modification which it would seem advisable to make later. The motion was unanimously carried. Mr. Evans moved that the banquet for the A. F. A. and A. I. M. for the 1914 convention conform in general to the plan of that followed in Buffalo in 1912, and that cabaret features be eliminated. The motion carried without a negative vote.

Major Speer offered a motion to form a committee of 15 to consist of three members of each of the four permanent organizations interested in the 1914 convention, together with three representatives of Chicago foundrymen to convene after adjournment of this session with power to act, to complete details for program and entertainment for the September convention, each organization to select its committee of three. The motion was carried unanimously.

Upon inquiry, Mr. Perkins stated that the executive committee of the F. & M. E. Co. had unanimously expressed the opinion that the 1915 foundrymen's meeting should be held in the east. Upon motion by Mr. McFadden it was recorded as being the sense of this joint meeting that the 1915 foundrymen's meeting be held in the east, about June 1.

President Howell stated that he had word from Dr. Moldenke that a party of German foundrymen expect to visit the United States in March, 1914, and that a question concerning the entertainment of these gentlemen had been raised. Mr. Abell's suggestion was adopted by consent without formal motion that Dr. Moldenke write to the local foundrymen's associations in the various cities advising them of the visit of these gentlemen with the idea that such local associations will be glad to arrange for suitable entertainment features.

Considerable discussion was had concerning the plan of compensating certain writers of papers for railroad fare and hotel expenses and it seemed to be the opinion of all that such a plan would prove helpful toward securing good papers. Following a suggestion by Mr. McFadden that the F. & M. E. Co. might provide a certain amount for this specific purpose,

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Mr. Perkins held a short conference with members of his executive committee, and immediately thereafter announced that the F. & M. E. Co. would give $750 toward the expenses of the convention, said amount to be divided and spent as may seem proper to the A. F. A., A. I. M. and A. F. F. It was the consensus of opinion that this amount may be used for compensating certain writers of papers for their necessary expenses, but leaves the expenditure of this sum entirely at the discretion of the three organizations. Mr. Perkins' announcement met with instant and hearty approval. No decision was reached as to how this fund shall be divided among the three associations.

Upon motion by Major Speer, the meeting was adjourned to convene at the call of Chairman Howell.

R. A. BULL,
Secretary Joint Foundry Convention Committee.

Approved:
ALFRED E. HOWELL, Chairman.

Minutes of the Joint Foundry Convention Program Committee, Held at the Hotel La Salle, Chicago, Jan. 17, 1914.

The meeting of the joint foundry convention program committee was called to order at the Hotel La Salle, Chicago, at 5 p. m., Jan. 17. Alfred E. Howell, president of the American Foundrymen's Association was elected chairman, and R. A. Bull, secretary. The following were in attendance:

American Foundrymen's Association: Alfred E. Howell, L. L. Anthes and R. A. Bull.

American Institute of Metals: G. H. Clamer and W. M. Corse.

Associated Foundry Foremen: S. V. Blair and Robert B. Thomson.

Foundry & Machine Exhibition Co.: F. N. Perkins, J. H. McCormick, R. S. Buch and C. E. Hoyt.

Chicago Foundrymen: C. B. Carter, Oliver J. Abell and S. T. Johnston.

It was announced that the Hotel La Salle had been selected headquarters for the American Foundrymen's Association and the American Institute of Metals, and that the Fort Dearborn hotel had been selected headquarters for the Associated Foundry Foremen.

A tentative program then was adopted, subject to changes which might be necessary.

It was agreed that tickets to the "White City" concessions shall be issued at the exhibit, good at any time during the week.

Upon motion by Mr. Corse, it was voted unanimously to issue to one person representing each member of the A. F. A. and A. I. M. having personal representation at the convention, one ticket gratis to the Thursday banquet; also to issue gratis to each member of the A. F. F. in personal attendance one ticket to the Monday banquet, and further to permit without restriction tickets to be sold to the Thursday banquet at $4.00 per plate and to the Monday banquet, at $3.00 per plate.

Some discussion was had concerning a proposed trip to Milwaukee to visit the foundries at that point and since there does not seem to be sufficient time to permit such a trip, Mr. Abell moved that it be eliminated from a place on the program.

President Howell requested the representatives of the F. & M. E. Co. and the Chicago foundrymen to meet and to advise with each other from time to time concerning the program details not settled upon.

It was agreed that no publicity should be given the tentative program and that future announcements shall be made only as authorized by the joint committee.

Upon motion by Mr. Anthes the meeting was adjourned subject to the call of the chairman.

R. A. BULL,

Secretary Joint Foundry Convention Program Committee.

Approved:

ALFRED E. HOWELL, Chairman.

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Appointment of Secretary-Treasurer

Immediately following the meeting of the executive committee of the American Foundrymen's Association, held at the Hotel La Salle, Chicago, Jan. 17, 1914, Alfred E. Howell, president, tendered Dr. Richard Moldenke the office of editorial and foreign secretary, and A. O. Backert, of Cleveland, the office of acting secretary-treasurer. Dr. Moldenke refused to accept the office created by the executive committee and announced that he would sever his official affiliation with the American Foundrymen's Association upon the completion of his work on Vol. 22 of the *Transactions*.

The office of secretary-treasurer, to include all duties performed for the association by Dr. Richard Moldenke, then was tendered by President Howell to A. O. Backert, and following his acceptance, he assumed the duties of the office of secretary-treasurer of the A. F. A. on April 1, 1914.

Meeting of the President, Senior Vice President, Secretary-Treasurer and Chairman of the Program Committee of the A. F. A., at Chicago, April 4, 1914

To outline the program for the convention of the American Foundrymen's Association, to be held at Chicago, Sept. 7 to 12, a special meeting was called by President Alfred E. Howell, which was held at the Hotel La Salle, Chicago, April 4. The following were in attendance:

Alfred E. Howell, president; R. A. Bull, senior vice president; A. O. Backert, secretary-treasurer, and H. B. Swan, Detroit, representing Jos. J. Wilson, chairman of the program committee.

The program of papers was outlined, including the entertainment features.

At noon, the officers of the association were guests of the members of the Chicago local convention committee, at a delightful luncheon served at the Hotel La Salle.

A. O. Backert, Secretary-Treasurer.
Alfred E. Howell, President.

The Value of Co-operation

Annual Address by the President, Alfred E. Howell

Our experience at this convention of the Allied Associations suggests the theme about which I shall say a very few words, and that is the value and wisdom of co-operation. Every age has what we call the "spirit of the times", and this century will be known in history chiefly for the extraordinary advance of knowledge and for the economic transformation involved in the passage from little affairs to big affairs. This transformation can only take place by the co-ordinated and correlated effort of the many units working in harmony for the one general purpose. The big results, seem to have come to those men, who by their intuition, their *genius,* if you will, for organization, have blazed the way to phenomenal success. We see this in America, which has become the home of big business, more especially than any other country.

The first time that I can recall that this co-operation on a large scale of vast and ramifying interests was put into practice was in Chicago, the occasion being the World's Fair or "Columbian Exposition" of 1893, which will always seem to me the most marvelous creation that the world had ever seen up to that time and which I believe has never been surpassed, nor can be, in scope and artistic perfection and the wonderful and harmonious working-out of every detail. This was, by the way, but a short time before our association was projected and launched on its career of usefulness. It seems somewhat the fashion nowadays to decry big business, but I feel convinced that the correct judgment should be based on conduct and not on size.

By analyzing the methods of those who have achieved phenomenal results, there has been evolved the science of business and the "Efficiency Engineer" is a recognized factor. I ran across, a few davs ago, an illustration of what I mean,

in a report to the London (England) County Council on London's electricity supply. An engineering firm found that England's greatest city is now served by 65 companies, operating 70 generating stations, using 31 different systems of generation, eight different frequencies, 21 different distributing voltages and 50 separate methods of charging the consumer for what he gets. The waste and vexation caused by this confusion must be incalculable. The planless, piecemeal policy has come to the end of its rope, and it is now proposed to have one huge generating station and retire the bric-a-brac as fast as possible.

The material framework of modern civilization is its industrial system and the directing force which animates this framework is business enterprise. The business enterprise in which each of us is engaged when he is at home, is, of course, conducted for profit. And yet we know of many vast enterprises that are carried on for mutual benefit or the betterment of conditions, that are conducted without expectation or hope of money reward. Ours is one of these—do not understand me to deprecate money reward. As Dr. Oliver Wendell Holmes said, "Money is a great means of refinement," and without a modicum of financial success, few of us would be at this elegant board this evening. But there is something greater than money reward, and that is the achievement of results that may make the condition of those who follow after us the better that we have lived, and add to the orderly progress in science and industry by our foresight and example of wise fellowship in human endeavor.

The spirit of modern industry is expressed in the machine. This may not at first seem altogether true, but it *is,* to such an extent and in such a pervasive manner that a modern industrial community cannot go on, except by the help of accepted mechanical appliances and processes. In its bearing on modern life and modern business the "machine process" means something more comprehensive than a mere aggregate of mechanical appliances to be used by the laborer that attends them. The civil engineer, the mechanical engineer, the mining expert, the industrial chemist, the mineralogist, the metallurgist, the elec-

trician, all fall within the lines of the modern machine process, as well as the work of the inventor, who devises the appliances and the mechanician who puts the inventions into effect and oversees them. Chemical properties are counted on in carrying out metallurgical processes, with much the same certainty as mechanical appliances. Wherever manual dexterity, the "rule of thumb" has been supplanted by a reasoned procedure on the basis of a systematic knowledge of the forces employed, there mechanical industry is to be found.

This comprehensive industrial process draws into its scope and turns to account all branches of knowledge that have to do with the material sciences. The requirement of mechanical accuracy has led to a gradual enforcement of uniformity, to a reduction to staple grades and character in materials handled, and to standardization of tools and units of measurement. The adjustment and adaptation of part to part, and of process to process, has passed out of the category of craftsmanlike skill, into that of mechanical standardization. Hence, perhaps, the great gain in productive efficiency through modern methods, and the large saving of labor in modern industry. But mark you, there is no independence—there is increasing dependence or interdependence.

I have indulged in these generalizations applicable to the business of each of us, for the purpose of suggesting the intimacy of the scientific with the mechanical. The chemist, metallurgist and engineer must collaborate with the mechanician, and with those who supply the materials of construction in order to get results. How little could we appreciate the scientific genius of an Edison or a Marconi were it not for those wonderful mechanisms which they devised, inspired and directed, giving us the tangible results which contribute so wonderfully to the pleasure and uplift of mankind.

Knowledge is of two kinds. We know a subject ourselves or we know where we can find information upon it. Let us make our association the source of all needed information relative to the great industries in which we are engaged, and by enthusiasm, spurn inaction. Enthusiasm is the greatest business asset in the world. It beats money and power and

influence. Enthusiasm tramples over prejudice and like an avalanche, overwhelms all obstacles. Set the germ of enthusiasm afloat in your works, carry it in your attitude and manner. It spreads like contagion and influences every fiber of your industry before you realize it. It begets and inspires effects you did not dream of. It means increase in production and decrease in costs; it means joy and pleasure and satisfaction to your workers. To the officers and the members of the committees of your association, it means spontaneous and active service for you, it means results. Give them your enthusiastic support.

Gentlemen: I speak feelingly when I say—give them this support, for I know what it means, I have had it given by them to me—by Mr. Clamer, Mr. Corse, Mr. Blair, Mr. Thompson, Mr. Perkins, Mr. Hoyt, Mr. Wilson, Mr. Swan, Mr. Lange, Mr. Evans. To all these names that you see as officers and committeemen, and all those gentlemen who have given us such a splendid array of papers and discussions, I am deeply indebted.

It became my duty, since last we met, to appoint a secretary, to succeed Dr. Richard Moldenke, for so many years the valued, efficient, and indefatigable secretary of the American Foundrymen's Association. The gentleman appointed to this difficult and exacting post was Mr. A. O. Backert.

There is another gentleman without whose assistance I am afraid I would have felt completely lost and overwhelmed by the thought of the responsibilities of my office. From him I have received unwavering support, the most constant good fellowship, and wise, tactful and valuable help. I refer to Mr. R. A. Bull, your senior vice president.

In closing, please let me say that besides these I have mentioned there were others, but especially three gentlemen, each of whom have served this association as its chief executive, possibly as it can never be served again; men whose wisdom, counsel and guidance came to me as a benediction, men whom this association never will nor can forget—Mr. McFadden, Major Speer and Joseph S. Seaman, by whose presence we are honored this evening.

These men have served us, and left us richer for the inspiration of their lives and the kindliness of their great hearts. It is right that others should take up and carry on the work for which they blazed the way, and endeavor to so work out the destiny of this association as to be worthy of their ideals.

Some By-Products of Commerce and Industry

Banquet Address by Dr. James H. Kirkland, Chancellor of Vanderbilt University, Nashville, Tenn.

I am very much puzzled to know how to begin, whether to commend the caution of the gentleman of Chicago who hesitates to vouch for a man that he doesn't know any too well, or the recklessness of the man from the south who knows that he is going to leave your city by the next train and cannot be held responsible for what he says. I beg to say, however, in my opening words, that I am deeply grateful for the privilege of appearing before you. I consider it a high honor indeed. I am reminded, not by similarity at all, but by way of contrast, of an occasion in the state of Kentucky when a Methodist minister of some repute for repartee and general humor happened to drop into a Republican convention. This Methodist minister from the state of Kentucky had, of course, voted the Democratic ticket all his life. The chairman of the meeting, seeing him there, sent the usher down and said, "Dr. Cottrell, the chairman begs you will come up and open the meeting with prayer." "No, no," he said. "But," the usher says, "you must, doctor." "Oh, no, I can't do it." "Well, why, doctor?" "Why," he said, "I don't want the Lord to know I am here."

By way of contrast, ladies and gentlemen, I trust that when the recording angel is making a statement of my sins of omission and commission, he will not forget to enter to my credit that on one most auspicious occasion I was deemed worthy of your association and to be taken into this sacred brotherhood for one hour. It has been also a very great gratification to me to be present in Chicago. Now, Chicago does not belong to itself, it belongs to our whole nation, and we are all proud of it. But we never know all the virtues of Chicago until we come here and hear a Chicago man talk about

it. Again, by way, not of similarity, but of contrast, I beg you to remember, I will tell a little story on the city of Atlanta, for I am far enough away from Atlanta now to tell it. When an Atlanta man was boasting to a gentleman from New York what his city was doing, he said, "All in the world Atlanta needs is water, water. If we had water, we would soon be equal to New York." The New York gentleman very quickly replied, "If you will just run a three-inch pipe from Savannah to Atlanta and if you people of Atlanta will suck as hard as you blow, you will soon have all the water you want."

What can a college man say on such an occasion as this? It is hard for me to find in my list of subjects, indeed, anything that seems appropriate to this gathering. I would not dare undertake to discuss before this body of scientific men any problems that you are familiar with. Perhaps all that I can hope to do is to create a sense of sympathy, to assure you that there are close ties that bind together educational workers and business men. Commercial life and university life are parts of our great American civilization and they are parts that belong together and should not be separated. The theme which I have selected for the program is in a general way that of by-products. This suggests all kinds of subjects to each one of you, broad as the world. The learned man might talk very learnedly about it and the ignorant man, such as I am, may hope, for a few minutes, to hide under its sheltering phrases. By-products—college life has them as well as your business. In our life they are known as foot ball contests, general athletic performances, night shirt parades and the students frequently think the by-products the principal part of the performance.

My general theme is that universities are, in a sense, the by-products of commercial and industrial life. Perhaps I should rather put it this way, that both commerce and industry and educational work, on the other hand, are co-products of our common civilization, of our American life, of American ideas and ideals, and that both belong together. I take it you will admit very readily that commercial and industrial life is an intellectual process and is successful just in proportion as

the intellectual process dominates the manual. If I were to undertake to lay down any general foundation of business rules, foundations for business success, I should say that there were two or three factors. The first factor is scientific achievement, invention, discovery. The second factor is a proper relation to economic laws and a proper adjustment of business to all the demands of private and public economy. The third factor is political—legislation—that helps and does not hinder business. Now, it is only with the first of these that I am concerned, and I call you to witness and I call to your memory the extent to which your own business affairs depend upon scientific achievement. Back of every process that you are engaged in lie patents innumerable and discoveries innumerable that were never patented. Your business world is a school; all commercial life is a great university; the wise men go to the top; the dunce remains at the foot. Day by day we learn our lessons of business as we used to learn the lessons of the school room.

It is more than a hundred years since Adam Smith published his *Wealth of Nations*. In that work he marvelled at the tremendous development of machinery and the extent to which it was supplementing the human hand and called attention to the fact that one man could make approximately 50,000 pins in a day. Today one man can make 50 times as many. Mr. Atkinson has calculated that the labor of one man in an improved cotton mill can produce in one year enough cloth to clothe 1,000 fully clothed Chinamen or 3,000 partially clothed East Indians. It has also been calculated that the labor of one man directed in the most approved channels can produce 5,000 bushels of wheat, and the labor of another man in the mills can turn that into a thousand barrels of flour. It is stated that in the United States we now employ mechanically 30,000,000 horsepower, equal to perhaps 360,000,000 manpower. Now, those are just a few flash lights. I beg you to remember that all of this work is the product not of the human hand, but of the human brain; and therefore that your profession, your business, your association represents preeminently the triumph of mind over matter, the accomplish-

ment in a tangible form before us, in a way essential to our life and happiness, of great results that men thought out and dreamed out. But now I want to proceed one step further and to remind you that the tie between your work and universities is closer perhaps than you think, for this reason; that back of all the mechanical and back of all the practical must lie the achievements of pure science. I am very well aware that when a man begins to talk to a practical man about the achievements of pure science, he is not listened to very sympathetically. Indeed some men go so far as to say that those things are incompatible. It is very much like the old darkey that I knew of, who was suffering from some kind or anaemia and was lying in bed, and he got his old friend, a young doctor, to come and see him, a man who had hunted with him and to whom he had told stories as a boy. This Doctor Bill, who was just back from the medical college, said, "Uncle Tom, you must be very careful of your health; lie up here, as you are doing, quietly, but you need nourishing food. I recommend especially chicken soup and the white meat of chicken." He says, "Doctor Bill, just stop right there. How in the world is this poor nigger going to have chicken soup and white meat of chickens and lie in bed day and night?" There were incompatibilities in the prescription; but there is no incompatibility between pure science and applied science. Gentlemen, we heard tonight of Marconi, the wonderful story of the last ten or fifteen years, the achievements of wireless telegraphy. I was reading the other day this splendid tribute to that discovery, that within the last ten years not a ship on the ocean had sent its cry out across the dark waters for help that it had not been heard and answered; not, of course, that every individual had been saved, but the cry had been heard and the answer had come. But back of Marconi there was Hertz in Germany, Clerk Maxwell in England, and if these men had not worked in the theory of electricity, there would have been, possibly, no Marconi, no wireless telegraphy of today. I presume there is nothing that is quite so unpractical, or supposed to be, as astronomy. The star gazer is the typical fool and yet, gentlemen, it is the

study of astronomy that has made possible the transportation of the goods of the world across the seas. The great merchant marine, the understanding of the tides and the control of commerce.

That great war that is being fought in Europe today is being fought not alone by soldiers, it is being fought by mathematicians. Gunners destroy forts they never see; chemists are fighting it—engineers and sanitary workers of all kinds. The fight is not simply by the man in the trenches. What is it that has given Germany her tremendous pre-eminence? It is chemistry, chemical industries of all kinds, chemical discoveries. It is the fact that some 40 years ago, when chemistry burst on the world and was almost a new science, Germany had its great universities, its laboratories, its trained workers, ready to take up chemistry and electricity and it was its pre-eminence in pure science that prepared the way for the tremendous advance in practical science. And do you know when modern chemistry was born? It was born when Priestley and others discovered oxygen, when a man took a lump of coal in his hand and said, "What is it that takes place when that lump of coal disappears into ashes?" Not a very profitable investigation. And the great discoveries in physics began when Pascal and Torricelli weighed the atmosphere. I am told that the General Electric Co. spends $75,000 annually on purely scientific laboratories, on men working in the theory of electrical science, not seeking at all a discovery that they expect to use today or tomorrow, but looking to the far distant future. In that way universities and practical science are brought together.

In one other direction, I might speak of universities as also reflecting modern civilization. You hear a great deal today of vocational education. Your own associations have interested themselves in it. Colleges and universities are reflecting this idea. The public schools are taking it up. Night schools are being established; schools for special trades and industries conducted by cities, by great commercial organizations, by manufacturing establishments, by railroads. So here.

there and yonder you find your cries immediately taken up by the educational world.

I have but one or two other remarks to make on this general theme of by-products. I think it is particularly interesting to note how civilization itself is in many cases a by-product of industry and commerce. I do not mean particularly our civilization that has come down through the ages, but I mean where civilization has driven its forces into some benighted land, it has been through the impelling power of commercial life that this has been done. The British Empire is not simply a dream; the British Empire is a piece of business and the greatest piece of business that has ever been operated on the human planet. It has been put into operation and is being maintained largely for business purposes. That is what opened Japan and that is what has opened China and that is what has opened Africa. There is pathos in that cry that has gone out from Germany in the last ten years for expansion, for a larger place in the sun, for a market where they can sell their goods.

But in our own life, too, in the civilization of our own country, a civilization long established and historic, there are by-products of commercial and industrial life that are no less interesting. First, there is the by-product of economy. Commercial life has been directed, very largely, to doing away with the waste of manufacture and turning the wasteful by-products into that which is profitable. I need not go outside of Chicago or outside of the Chicago stock yards to find the most illuminating illustration of that, how from the tip of the horn to the last hair of the tail, the animal is made to contribute to our welfare and to the wealth of the man who handles it. Now, I don't say whether we eat the horn or eat the tail, but it is a well-known fact that none of it is wasted, that it is all utilized as a source of wealth. The history of coal tar distillation would be a story as of Aladdin's lamp if developed in that way. Now, we all know that we have been reckless in our prodigality, wasteful of natural resources, wasteful of the by-products of manufacture, but we are learning a saner life, we are learning a better view, and your

profession, gentlemen, is re-acting on the whole world and teaching us the law of efficiency, the law of economy, the law of real achievement. It is not necessary that I should speak of another great by-product that your president alluded to very properly, that of organization and co-operation. I pass that by entirely.

May I, in conclusion, speak of another and one of the greatest by-products of commercial and industrial life, and that is peace and harmony and good will among communities and among the nations. It may seem like irony, gentlemen, it may seem like a grim humor, to talk about peace in this day, when, at every hour, you hear the cry of the streets, "War Extra." The nations of the world have gone mad; men have lost their reason and the world has turned apparently into a great cage of brutish beasts. War is not reason; it is the negation of reason, it is the negation of civilization, it is the negation of business, it is the negation of commerce, it is the negation of all that makes life valuable. We do not forget, we speak with sadness, even with shame; we recall the fact that half a century ago our own land was bathed in blood when brothers drew the sword against brothers, and when division and strife and bitterness and death were our portion. But the day has come since then when these things are remembered, but to be repented of. The day of friendly association has come about in this country, I venture to say, not chiefly through moralists, not because men have taught us that those things were wrong. I will venture to say it has not come through politics, for sometimes the politician has tried to keep alive the divisions that ought to have been forgotten and sectionalism has been made the stepping stone to personal preferment. Why, I remember, gentlemen, as a boy, a little boy, the associations I had with the word Republican. The only thing that could have surpassed it perhaps were the associations of some fellow way down yonder in New England with the word Democrat. I was down in Maine a couple of years ago, spent a summer there, way on the far coast of Maine. In that country, that self-satisfied corner of the United States, a fellow was acting as guide to a man from

New York and leading him about through the woods, trying to find a deer for him to shoot at, and this guide said, "Mister, where do you come from, anyhow?" And he said, "I come from New York." "Well," he said, "how fur is that from here?" "Oh," he says, "I suppose six hundred miles." "Well, Mister, ain't it awful to live that fur from everywhere?" Well, that was not my story that I started out with. From down there a fellow in Maine started on a tour down south and he was studying the political situation of the country, and when he got to Boston, he was surprised to find that there were a good many more Democrats than he knew were in existence; when he got to New York, the supply seemed greatly to increase, to his horror, and yet he went further down south, to Virginia and South Carolina. Then he wrote a letter back, telling of that most marvelous observation he had made, that the further south he had gone, the more Democrats he found, and that he was perfectly convinced that if he should pursue his journey to that land that knew neither snow nor ice, that was eternally hot, he'd find all the inhabitants Democrats. But what I was saying was that this union in our country had come, therefore, not through politicians, but that a restoration of harmony and good feeling has come, gentlemen, through men like yourselves, through business interests, through commercial life, through a recognition that we have, after all, the same interests at heart and the same work to do. May we not look forward, therefore, out of this time of darkness to the day when light shall break? May we not look forward to the hour when commerce shall assert itself and instead of dreadnaughts and mines covering the sea, the white sails of commerce shall again dot the blue waters and the business of the world shall be restored, and with it the fellowship of the world, and the good will of the world. And in that task it seems to me that America has a work to do. We have right before us now an opportunity for victories greater than those of war, for large achievements, commercially, for contributing to the civilization of the world, for not merely feeding, but supplying the world with manufactured goods, and the implements of daily life which the world must have. I

look upon this task, gentlemen, as a larger one than merely making money. I look upon it as a bigger proposition than merely getting some new outlet for trade. I look upon it as an opportunity for America to assert its leadership, its ideas of liberty, of personal freedom, and of service to humanity. In this day of darkness shall we not get ready for that hour, we pray soon to come, when America shall take the lead and help restore the world to an era of sanity? When the flames of cities going up in smoke shall be forgotten, and the fires of industry shall be lighted; when on every hillside and in every valley the forge and the anvil shall be started again; when civilization shall move forward to the sound of church bell and of college chimes; to the day when we shall hear no more the Wacht am Rhein or the Marsellaise, but in place of these war-like melodies all men, everywhere, shall unite in singing the song sung by angels over Bethlehem's plains, "Peace on earth, good will towards men."

Safety in Foundry Operations

Address by Magnus W. Alexander

Fortunately the time has gone by when it was necessary to preach accident prevention as a humane duty and an economic necessity of the employer in order to arouse his interest in the issue. The persistent pleading of some, by word of mouth and by force of example, and more recently the enactment of workmen's compensation laws in 24 states and its strong effect upon accident prevention, has created a universal interest in the elimination, or at least in the reduction of accidents and consequent damage to persons and property. Only a few years ago it was timely to call the employer's attention to his duty toward his workmen in matters of safety by quoting even so ancient a book as the Bible, which abounds in exhortation for the exercise of caution and order and safety.

What the employer needs today is not to be told why to promote safety in employment, but how to do it effectively, quickly, economically; direction as a guidance and not direction as an injunction is the call of the hour. There is a large body of evidence on hand to tell of accidents of various kinds and degrees and of their consequences, but this evidence must be studied and analyzed to find the cause of accidents, and having found them, to promulgate the best ways for their elimination or for effective guarding against their consequences. Research in safety and sanitation in employment, in the manner in which research in the technical phases of foundry work is carried on, must take the place of oratorical hysterics about the number of injured and killed, demanded as the yearly toll of our industries, and of superficial advice in regard to the safeguarding of machinery and premises, preached by some so-called safety engineers and inspectors whose oppor-

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tunist activity is largely based on a surface knowledge of the industries and their requirements and not upon a clear, intelligent, sound understanding of the work itself.

Most Frequent and Dangerous Hazards

What are the most frequent and the most dangerous hazards in foundry work and allied employments the elimination of, or the guarding against which would prevent most and the severest injuries? This fundamental question must engage our first thought. A careful study has revealed in the foundry industry as in other industries, that the cause of the majority of all accidents can be written with one word and with one word only—*Carelessness.* Somebody, the laborer, the mechanic, the molder, the foreman or the manager did not care enough, and that caused the accident. To turn this carelessness into care is the only remedy of the situation, and persistent education of the employer and the employe as to the value of and the necessity for personal care will accomplish the desired result. When once it will have been brought home to everyone so that it becomes part of his unconscious daily thinking, that *personal caution is the greatest safeguard,* then we shall see a reduction in the number of accidents in an astonishing degree. This problem permeates beyond the mechanical industries and beyond industrial employment into all employment, in fact, into all activities of our daily life. Because it is of such general character I shall, on this occasion, take time only to endeavor to fasten upon your mind and consciousness the plain truth that *personal caution is the greatest safeguard after all,* and to direct your attention to the many educational efforts for the promotion of safety which have been tried out at various places, even though not always with full success. In this way I hope to stimulate you to find new means of teaching every workman himself the significance and the value of personal caution.

Order Makes for Safety

The twin sister of caution is order; order makes for safety. How important this is in foundry work is hardly necessary to

mention to foundry experts. The foundry floor is the field of activity of the foundryman, and here particularly new situations are arising constantly, calling for quick and proper action. Many accidents in the foundry occur because the quick-moving man who carries the ladle with the molten metal stumbles over some castings or other obstruction in the aisles, sometimes over only a small tool. To keep the aisles free of obstruction and keep them wide enough that men can pass in opposite directions without jolting each other, must be an important duty of the foundry manager. The foundry yard on the other hand, is the gateway for all materials to and from the foundry; order in piling up castings, in the segregation of the various sands and the coal in properly constructed bins, is not only a matter of much importance from the standpoint of safety, but also from that of quick and economical production.

Personal Caution

Many accidents due to lack of personal caution can be avoided by calling the need for personal caution to the attention of the men. Proper warning signs of one kind and another will be of material help in this connection, for they will show where there are dangerous places and will serve as constant and untiring guards and mentors. These signs should not detract by their peculiar pictorial designs from the lesson which they are intended to preach, but should by their simplicity and directness attract attention to the very word *Danger* or *Caution*. The belief, therefore, is taking hold everywhere that plain signs in the accepted colors of danger, white and red, or of caution, white and green, should be used and that simple words should be inscribed on them so that these words will eventually become symbols, as today, for instance, skull and crossbones or Thor's fist from which lightning zig-zags emanate, are symbols of danger.

In foundries representatives of many nations are employed, many of them do not speak the English language nor are able to read it. On first thought it might be considered

wise to print for their benefit signs in their languages, and yet upon second thought the difficulty and even the impracticability of such a procedure will readily be seen. A sign in several languages will either become so large as to be unwieldy, or else the wording on the sign will be so small as not to be legible from a distance. When the foreigner once learns, by frequently looking at the word *Danger*, that that word stands for the corresponding word in his native tongue, he will have no difficulty in understanding the sign. It,

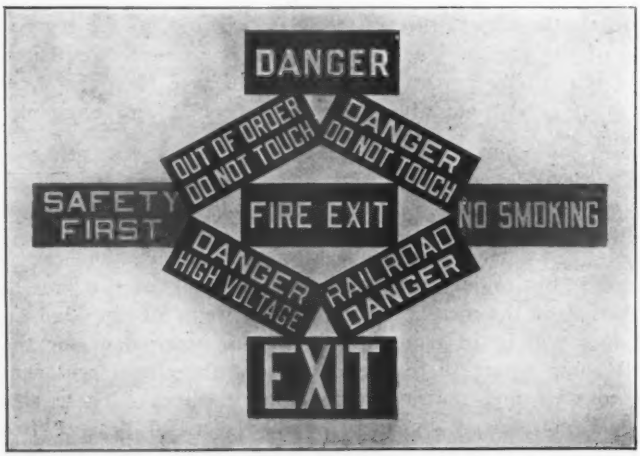
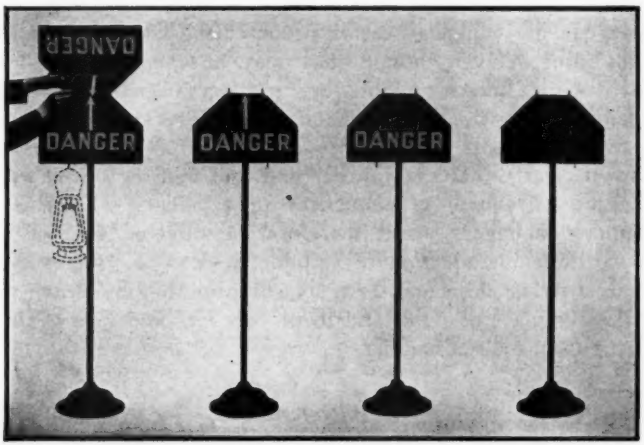


FIG. 1—APPROVED DANGER SIGNS AND SAFETY SIGNS MADE OF LINEN

therefore, is believed to be the best plan to print signs in English only, in plain manner and in accepted colors. In some cases other wording will be necessary, than the simple word *Danger*. The electrical industry needs signs that point out high voltage; the machine shops require signs which tell that a machine is out of order; attention must be called to apparatus that must not be touched; people must be warned to look out for an approaching train. Wherever possible, the word *Danger* should be worked into the sign,

which should not have more than two lines. Signs of this kind are illustrated in Fig. 1.

On the other hand, there may be a danger above the working man; a crane may be under repair or the roof structure may be dangerous, and the employe must be warned as he approaches the spot and long before he gets to the spot, that he should be aware of the danger above. Such signs will usually have to stand on the floor, often they will have



Note the three sign plates, also hook for lantern at night | Arrow exposed (on both sides) to warn of overhead danger | Arrow covered (on both sides) to warn of surface danger | All warning folded out of sight when there is no danger

FIG. 2—APPROVED METAL DANGER SIGN

to be put out in the yard. A metal danger sign should then be used because it will best withstand the conditions of the weather and the ordinary wear and tear. Again, the symbol *Danger* should appear on it; moreover, there should also be painted on it an arrow to point to the source of danger. Often, however, the danger may not be from above; it may be a hole in the ground that should be pointed out. In order to use this sign more universally, it is best to paint the

arrow on one side of the sign plate and also on one side of a separate plate, so that the arrow will show on both sides, or on neither according to whether the separate plate is turned one way or the other. This metal sign is shown in Fig. 2.

There are many hazards in foundries which cannot be guarded against merely by the exercise of personal caution. Splashing of metal will occur in spite of carefulness and workmen must, therefore, use devices to protect themselves against the resulting consequences. Similarly, employes engaged in chipping castings are liable to have their eyes injured, even though they may be ever so careful in their work, unless suitable eye protectors guard the eyes against injury from flying metal chips. The study of thousands of accidents in foundries and related departments has shown clearly that eye injuries and foot and leg burns were the most frequent consequences of accidents. Efforts of foundry managers must, therefore, be directed first of all toward the introduction of suitable devices to protect eyes against flying chips and dust, splashing molten metal and the excessive glare of light, and to protect feet and legs against burns from molten metal.

Eye Protectors

The best eye protectors which I have found by investigation and experience are goggles with large, round lenses, of various colors and thicknesses to suit various conditions of service, with flexible bridges and with suitable side protectors. The lenses should be large in size and round in shape in order to give a large field of vision and to make it possible to wear the goggles over ordinary eye-glasses where these are necessary for corrective purposes of the eyes. It would obviously be too expensive to put corrective lenses into goggles where they may easily be marred. The bridge of the goggles should be made of flexible material so that each pair of goggles can readily be adjusted to the shape of the wearer's face. Foremen should demonstrate this feature

to the employes who otherwise might complain that the goggles do not fit comfortably and, therefore, might be unwilling to wear them. Some effort on the part of foremen in explaining protective devices to the workmen and in adjusting the same for them will go a long way toward overcoming a natural disinclination to wear such devices.

All goggles should be provided with side protectors; these may be made of perforated leather or of metal screen. While the use of leather side protectors makes the goggles lighter in weight and allows easier and more comfortable adjustment of the same to the face than can be secured by the use of metal side shields, either type offers satisfactory protection and the selection of the type becomes usually a matter of personal preference. One man claims to feel harnessed when wearing goggles with metal side shields, and another objects to leather side protectors because of their less sanitary character. The latter objection is of theoretical rather than practical nature, for the same goggles are usually worn by the same man, and the question of unsanitary character of the goggles, therefore, does not need to enter into consideration; moreover, leather side protectors can be cleansed, if it should become necessary when a pair of such goggles is given to one man after they had already been worn by another. In any event, the side protectors should be permanently fastened to the goggle frame so that they cannot be removed by the workman, for they will not usually replace them. Both types are shown in Fig. 3.

In order to suit various conditions of service, some goggles must be provided with thin and others with heavy lenses. In most instances thin lenses will serve the purpose of protecting the eyes, and heavy lenses will be required only by employes whose eyes are apt to be injured from flying, heavy metal chips. While it is of course desirable to have the lenses withstand the impact of flying particles without breaking generally the interposition of the lens between the eye itself and the flying particle, so as to impede the onrush of the latter long enough to give the eye time to close, will prove a sufficient protection. Nature has pro-

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vided the eyelid as a guard for the eye against injury from outside sources; "quick as a wink" the eyelid falls over the eye as a foreign substance approaches it. The advantage of thick lenses which will not break under the impact of flying chips must be considered as against the disadvantages of the heavy weight of such goggles and the resulting discomfort of wearing the same.

Some goggles should have clear lenses merely for the protection of the eyes against dust and flying particles; others, in order to eliminate the harmful influence of intensified light on the eye, need lenses of amber or smoke color, while for the use of steel melters dark blue lenses, and for oxy-

FIG. 3—SAFETY GOGGLES WITH LEATHER SIDE PROTECTORS AND WITH METAL SIDE PROTECTORS

acetylene welders lenses of a greenish tint are required. The eyes of the arc welder, on the other hand, should not only be protected by lenses of a dense violet color, usually secured by a combination of red and blue glasses, but in this case the protective lenses must be fastened in a hood which will at the same time shield the head of the arc welder from the excessive heat radiated from the arc. A number of devices have been brought out of late to serve as arc welders' hoods or helmets. Some have been made of aluminum, but metal hoods have been found to heat up readily and to be unsatisfactory for that reason; others have been made of wood in the shape of square boxes with open ends, in the front of which the protective lenses are inserted. Such a wooden

hood is placed by the arc welder over his head so that it rests on his shoulders while the welding process is going on, and he removes it when the electric current is cut off and his eyes, therefore, are no longer subjected to dangerous glare.

A metal helmet has recently been proposed, which is designed to be fastened to the head by means of a metal band provided with a swivel arrangement, so that the helmet may be readily thrown back when clear vision of the eyes is required. The objection to the swivel arrangement lies in the liability of the helmet falling in front of the arc welder's face when he is bending forward sufficiently, thereby obstructing his vision at an inopportune moment, perhaps even causing an accident in consequence of it. While wooden hoods have so far given most satisfaction, the problem of the arc welder's helmet has not yet been solved and further experimentation will be needed to produce a satisfactory protective device for arc welders.

Foot Burns

More frequent in foundry service than eye injuries are foot burns, due to the splashing of molten metal. Investigation of foot burns reveals the fact that most of them are brought about by the use of faulty or defective shoes. Of the four types of shoes in general use, namely, low oxford shoes, high button, lace and congress shoes, the latter obviously recommend themselves at once as being best for foundry workers. Congress type shoes, the uppers of which are made of one smooth piece of leather, readily shed molten metal as it splashes on the shoe, and do not offer the openings or projections of lace or button shoes, to hold the molten metal and allow it to burn through to the skin. Congress shoes have also a great advantage over other types in that they can be quickly taken off when molten metal has burned through them, for then it becomes important to remove the molten metal from the foot without delay and quickly give the burned foot proper treatment. Yet a

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congress shoe, to be fit for foundry workers, must be made with due regard to the service to which it is to be subjected. A shoe of this type is shown in Fig. 4.

First of all, the upper leather must be able to withstand, without cracking or breaking, the great changes of temperature in foundry service, from the cold temperature in winter in the foundry yard, where the shoe often gets water-soaked, to the high temperature around a furnace when the hot metal is being drawn off. A cracked or broken shoe is almost worse than none, for the wearing of the shoe gives the workman the idea that he is adequately protected against

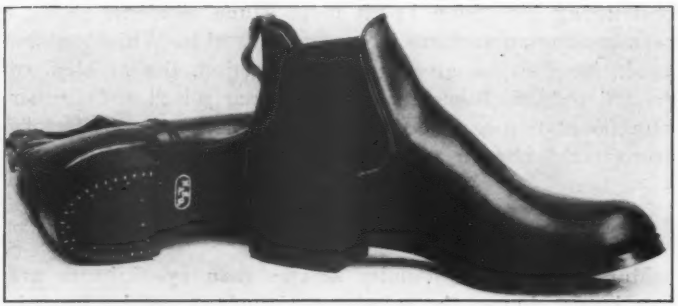

FIG. 4—SAFE FOUNDRY SHOES

the consequences of splashing metal and that he, therefore, does not need to exercise any particular care, when as a matter of fact he has no such protection when wearing a defective shoe. Shoe leather is either bark-tanned or chrome-tanned. Bark-tanned leather is apt to crack and break when subjected to the alternate influence of dampness and cold and of high temperature, while chrome-tanned leather is fairly waterproof and less affected by temperature changes. Foundry shoes should be made, therefore, with chrome-tanned uppers.

Second, the shoes must be provided with elastic goring that will not lose its elasticity under the constant stretching that the putting-on and taking-off of the shoe necessitates.

The top of the shoe should always fit snugly around the leg, for if the goring should stretch and the top, therefore, not fit snugly, the shoe would present an opening at the top through which molten metal could readily enter. The extra expense of a guaranteed goring of best quality would seem to be fully justified in the added protective value of the shoe.

Third, foundry shoes should not only be provided with heavy soles to give good wear and comfort to the wearer, but the soles must not extend beyond the uppers as otherwise the molten metal would have a chance to lodge on the protruding soles and burn through.

Finally, inasmuch as the usual pull strap which extends upwards from the top of the shoe is liable to catch the trouser legs and prevent them from coming over the shoe, the pull strap should be made to extend downward as a part of the back-stay of the shoe.

Foundry Leggings

With proper shoes foundry workers ought to be quite well safeguarded against foot burns; they may, nevertheless, suffer injury from molten metal when the same splashes against the leg above the shoe. It is obvious, therefore, that suitable leg protectors should also be provided. Workers in many foundries have been wearing so-called army leggings as protectors and have avoided many leg burns by their use. In studying the situation it has been found that army leggings are not entirely suitable for this purpose. The hood of the army legging, which extends forward over the shoe, while appearing at first sight to be a very desirable feature, is objectionable because it is apt to curl up and then form a basin for molten metal to lodge in. This tendency may be overcome by strapping down the hood; a great disadvantage, however, is at once introduced in that a legging so strapped down cannot be removed quickly. Army leggings possess also the objectionable feature of straps or buckles by means of which they are held around the leg. Any protruding part is undesirable because it gives the molten metal a chance to

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lodge there and burn through to the flesh. Moreover, leggings of this construction will fit snugly only the size of leg for which they have been made. It would prove very inconvenient to an employer to keep on hand a large number of leggings of different sizes in order that each foundry worker could be properly fitted.

I have developed a foundry legging which seems to eliminate the objections just referred to. This legging is

FIG. 5—FOUNDRY LEGGING IN COMBINATION WITH FOUNDRY SHOE

shown in Fig. 5. The fundamental idea of the legging construction is based on the use of a pair of spring clips similar to those used by bicycle riders to prevent their trouser legs from catching in the bicycle sprocket or chain. These clips are made of steel of about 1-inch width and of such flexibility that they can be opened wide without breaking. A piece of suitable canvas is stretched over an upper and a lower clip and the part of canvas above the upper clip is drawn in sufficiently so as always to fit snugly around the leg; the

canvas extends also in V-shape below the lower clip to cover the goring of the foundry shoe. The legging has no extension hood, for a hood is entirely unnecessary when the legging is worn with congress type shoes; foundry workers should be encouraged and if necessary obliged to wear such shoes whether or not they also wear foundry leggings. The above legging can quickly be put on and as quickly removed from the leg. It will fit a stout as well as a slim leg so that only one size needs to be kept for the convenience and use of all foundry workers. A flap on the back of the legging, to be tucked in after the legging is put on, will cover even the back part of the leg so that it may not be injured by the spilling of metal from a hand ladle carried by a man walking behind another. Canvas has been selected on account of its cheapness and its comfort to the wearer. While leather or asbestos would of course withstand molten metal much better than canvas, a legging made of either of these materials would be stiff and uncomfortable and would also materially increase the cost of manufacture.

Leggings Furnished Free

Different from foundry shoes, leggings are usually furnished to foundry workers free of charge by their employers, for they do not constitute a part of the ordinary wearing apparel, are put on only during foundry service and left by the workmen in the stockroom at the end of the day's work. Foundry shoes, on the other hand, are usually worn by the workmen inside as well as outside the foundry, and they should, therefore, be sold to the employes.

An investigation of accident records in several large foundries has clearly shown that since the use of foundry shoes and foundry leggings has been insisted upon in these foundries, foot and leg burns have largely disappeared where heretofore they formed a great percentage of all injuries to workers in foundries.

Other protective devices are used in foundries; they need constant improvement, however, to make them render the best service under all conditions. Many more devices must yet be developed to further eliminate foundry accidents; the time at this occasion does not permit to dwell upon their character. Let it be remembered, however, that it should be an important function of foundry managers and superintendents to deal adequately with accident prevention; this issue must play a major part in foundry management.

Electrocution of Employes

In spite of all efforts for their prevention, accidents will nevertheless occur; some cannot be prevented and others will be caused by the carelessness or heedlessness of employes or employers. After accidents have happened, it becomes at once a vital issue to minimize the consequences of injuries resulting therefrom, in order to restore the injured quickly to industrial usefulness. Large concerns can and ought to afford the employment of physicians for the treatment of injured employes; smaller concerns may not be able to do it and therefore, may be obliged to rely on periodical visits of physicians to their factories or upon the calling in of nearby physicians whenever their service is required. Whether the one or the other scheme is carried out, it will nevertheless be found advisable and even necessary to have specially selected men in each plant trained in first aid treatment of injured employes. Their training should be under the direction of regular physicians, who should repeat first aid lectures often enough to keep the first aid men in practice. Instruction should concern itself with the treatment of slight injuries such as cuts to the fingers, as well as with first aid to employes suffering more serious injury; moreover, it should include practice in resuscitation by the prone pressure method. Inasmuch as most foundries use electric current for one purpose or another, for lighting or in connection with electric furnaces, and often also for motor-driven machinery, electrocution of employes is a possible occurrence; in this case as well as in cases of unconsciousness from

asphyxiation by gas or smoke, quick application of artificial respiration is essential, and trained men should always be available for this purpose.

First Aid Directions

First aid directions, to be effective, must be concise and clear; they do not need to contain any explanation but only a brief description of the methods to be used, provided it can be assumed with confidence that the directions have had the approval of competent medical men. The National Founders' Association has given much attention to this question and has worked out in conference with many physicians excellent first aid directions; these are printed in the Association's *N. F. A. Safety Bulletin,* No. 17. Their adoption is recommended.

In connection with it, that Association has also standardized a First Aid Outfit, which I developed for the easy, convenient and sanitary storage and handling of the medicaments, bandages and tools necessary for the carrying out of the first aid directions. These paraphernalia were agreed upon by the same physicians who standardized the first aid directions. The effort was to select such remedies as would prove most harmless when handled by laymen, and which, as far as possible, could readily be obtained in drug stores.

Glass Jar Principal Container

I selected a glass jar as the principal container because it permits of a more sanitary outfit than could be obtained by the ordinary wooden or metal box usually employed for first aid kits. The glass jar rests in a wire cage with extension fingers which rest on the cover of the jar and make the jar quite dust-proof on account of the rubber ring placed between the jar and its cover. Along the inside wall of the jar are grouped six glass bottles, each containing one of the prescribed medicaments and each labeled with the name of the contents, the use to which it is to be put and the dose usually required. The bottles are of such height that when

FIG. 6—STANDARD FIRST AID JAR AND CONTENTS
(Illustration shows both sides of jar and cover.)

1 Tourniquet
1 pair nickel-plated scissors
1 pair nickel-plated tweezers
1 triangular sling
1 wire gauze splint
12 assorted safety pins
1 2-oz. bottle castor oil
2 3-oz. tubes burn ointment
1 2-oz. bottle 3 per cent alcoholic iodine
1 2-oz. bottle white wine vinegar
1 2-oz. bottle 4 per cent aqueous boric acid
1 2-oz. bottle aromatic spirit of ammonia
1 2-oz. bottle Jamaica ginger (or substitute)
1 piece of flannel 24 x 36-inch
1 roll absorbent cotton, 1.5 oz.
1 roll 3 inch x 10 yds. gauze bandage
1 roll 2-inch x 10 yds. gauze bandage
2 rolls 1-inch x 10 yds. gauze bandage
1 spool 1-inch x 5 yds. adhesive plaster
6 packages 6 x 36-inch sterile gauze
1 teaspoon
1 metal cup
1 medicine glass
2 medicine droppers
3 paper drinking cups
First aid record cards

corked they practically fill the space between the bottom and the cover of the jar. They are, moreover, held in place by a metal cup placed in the center of the jar and provided with wire prongs, between which the glass bottles sit. The remainder of the space between the metal cup and the inside wall of the jar is filled up with collapsible tubes containing burn ointment, with bandages of different widths and with

FIG. 3—STANDARD FIRST AID JAR
This arrangement allows the quick removal of any article without disturbing the rest

woven wire splint. The latter consists of a piece of woven wire about 30 inches long and 4 inches wide rolled up into a roll of about 1½-inch diameter. This splint, which has already been used successfully by the Red Cross Society and in hospitals, offers a good substitute for the ordinary wooden splint of about the same size. If a wooden splint were to be used it would have to be kept separate from the jar, with the result that it might get misplaced and not be available when

needed. The woven wire splint, on the other hand, can be cut to the required length to suit the condition of the fracture, and can also be so bent as to adjust itself to the shape of the broken limb and at the same time maintain the stiffness required of a splint.

Within the metal cup are placed such necessary tools as a tourniquet, safety pins, medicine glass, sanitary paper drinking cups, a piece of flannel, a pair of scissors, eye droppers, a spoon, a pair of tweezers, and a half dozen individual packages of sterile gauze. This arrangement allows most of the paraphernalia to be seen from the outside, particularly the medicaments and bandages, each of which can readily be removed from the jar after the cover has been lifted, and be replaced again in the jar without disarranging the other contents. If necessary, the metal cup can be used as a wash basin for an injured hand and the glass jar as a wash basin for an injured foot.

First Aid Directions

For the convenience of the first aid men and to avoid the loss or misplacement of a book of first aid directions, the latter have been printed on the inside of the jar cover, while on the outside of the cover appear some general directions for the care of the jar and a list of the standard contents. For shipping purposes and also as a protection against breakage in handling the jar within the foundry or workshop, the first aid jar is placed in a wooden container with cushions; the cover of the container, however, is cut out so as to allow the hand to reach in and carry the jar with its container on the regular handle cast into the cover of the jar.

First Aid Jar Standardized

This first aid jar has already found the approval and has been standardized by a large number of employers and physicians, and by several of the largest national employers' associations. The jar is put up under the direction and supervision of the National Founders' Association, which is

selling these jars with contents at practically the price of the materials, inasmuch as it does not intend to make any commercial profit out of the transaction but desires to be helpful to employers as well as employes in the adequate first aid treatment of injuries.

Is First Aid by Laymen Advisable?

The question as to whether first aid by laymen to injured employes is advisable or not is a somewhat mooted question. Some people would rather have the injured person suffer and his wound bleed until medical skill can be secured, than to take the chance of having additional harm done through the unskilled treatment of the wound by a layman. Yet if an artery is cut and life is in danger on account of the resulting excessive bleeding, when the quick and proper application of a tourniquet would temporarily stop the bleeding until the wound can receive adequate medical attention; if a person has become unconscious from an electric shock or asphyxiated by gas or smoke when immediate efforts for artificial respiration might retain the spark of life until a doctor can arrive on the scene and take charge of the patient; or if excessive pain can be relieved temporarily by proper means, it would not only seem advisable but become absolutely necessary that first aid treatment by the layman be given in all such cases. The objections of those who are ordinarily opposed to the practice of laymen treating wounds, even though they have been instructed in such treatment, can readily be overcome by the introduction of a system under which the first aid man would always make an adequate entry on a record card whenever he gives first aid attention to an injured person, and would promptly send the record card to the works physician, where there is one, or to the head office, so that all cases of first aid treatment can be followed up and injurious consequences be checked and prevented. The standard first aid jar contains a set of record cards with instructions for their use. In this way hundreds of minor injuries that happen daily in employment can receive adequate treatment by selected laymen, instead

of being inadequately treated by the injured persons themselves, and yet the recording and follow-up system just outlined will make such treatment safe and unobjectionable.

The Research Spirit

As stated in the beginning of my address, safety and sanitation work must be carried on in the research spirit. The causes of accidents and resultant injuries must be studied carefully in order that they may either be eliminated or effective means be found to guard against them. More harm than good may be done by superficial work in the field of safety and sanitation; a vast amount of good, on the other hand, can be accomplished if the problem is approached in the right way and worked out in a thorough manner. It will be well to carry into this work the thought which is expressed in Shakespeare's Hamlet, Act II, Scene 2:

It now remains that we find out the cause of this effect,
Or rather say the cause of this defect,
For this effect defective comes by cause.

Notes on Safety Organization

By A. W. Gregg and G. F. Kent, South Milwaukee, Wis.

In August, 1913, the National Council for Industrial Safety published the following facts concerning industries in the United States:

Every hour 232 workmen are killed or injured.
Every 15 minutes a workman is killed.
Every 16 seconds a workman is injured.
Every year 2,035,000 workmen are killed or injured.

The above figures are a sufficient explanation of the nation-wide campaign for safe working conditions. The National Council for Industrial Safety considered at least 50 per cent of the accidents investigated absolutely unnecessary.

Today every important organization of employers and employes in the United States has passed approval on the safety movement, and many of them have appointed safety committees, and publish bulletins dealing with safety devices and safeguards of all kinds for the benefit of their members. Nineteen states have passed empoyers' liability laws, which make it decidedly more costly (to say nothing of the humanitarian aspects) to injure a man than to provide safe working conditions for him.

The Bucyrus Co., at whose South Milwaukee plant both of the writers are employed, has been actively interested in safety work for more than eight years.

In February, 1913, the company elected to come under the provisions of the Wisconsin workmen's compensation act, and since that time has been carrying its own risk. Previous to this liability insurance was carried. For the last four years very careful records have been kept of all accidents and the

following figures show what has been accomplished in reduction of accidents:

Period.	Average No. of employes.	Accidents causing loss of 1 week or more.	Per cent.
Sept., 1910, to Sept., 1911....	1327	177	13.35
Sept., 1911, to Sept., 1912....	1236	101	8.17
Sept., 1912, to Sept., 1913....	1589	117	7.36
Sept., 1913, to Sept., 1914....	1113	53	4.76

This shows a reduction in serious accidents of more than 65 per cent, which was accomplished in spite of the fact that the company came under the provisions of the liability act in the middle of this four-year period, records all over the state showing that the period of disability increased under the liability act, due to the premium placed by it upon malingering.

It is not proposed in this paper to go into a detailed description of safety appliances and safeguards. We believe that by far the most important element in safety work is the organization provided to carry it on.

The Safety Organization

If there is provided an efficient organization, consisting of foremen and workmen, with power to act, safety devices will take care of themselves and be installed where conditions demand. In connection with safety devices it is an interesting fact that during 1913 the Bucyrus Co. had a total of 1,224 accidents in its South Milwaukee plant, and the records show that only six of them could have been prevented by a mechanical guard.

The National Founders' Association has adopted as a safety slogan, "Personal caution is the greatest safeguard after all." Their bulletin of October, 1913, says, "careful study of several thousand accidents in foundries in the United States clearly points to the impressive fact that more than nine-tenths of all serious accidents can be written with one word, *CARELESSNESS*. Most accidents happen when some one, the laborer, mechanic, molder, foreman or manager does not care enough."

Recognizing the fact that results could be accomplished only by a vigorous campaign conducted without any let-up, the Bucyrus Co., in January, 1911, appointed a safety committee to lay plans and to work up a spirit of co-operation among the men. This committee drew up a booklet of safety rules, a copy of which is furnished to every man in the company's employ and it also published a booklet of special rules for foremen, in which the responsibility for accidents is put squarely up to the man in charge. A few quotations from this booklet may prove of interest:

"You will be held responsible for accidents to your men. Remember that while every man is hired to do some particular work, the safety of himself and his fellow workmen is more important than that work. If any foreman has an accident in his gang, to that extent he is unsuccessful in his job. If he is not to blame but only unfortunate still he is not a valuable man for the company to keep in its employ."

In April, 1911, a permanent central committee consisting of the safety engineer, the works engineer, the foreman of the plant repair department and the foreman of the carpenter shop, was formed. This committee meets once a week and very carefully goes over all suggestions for the prevention of accidents. Once a month the committee selects two workmen to act as an inspection committee to spend one entire day in going over the plant, looking for dangerous conditions. These men are instructed to talk with employes of the different departments regarding safety and in this way the men in the shops have become very much interested and have made many valuable suggestions. These inspection committees average about 50 suggestions per trip, 90 per cent of which have been adopted by the central committee. In every department of the plant one man has been appointed to serve permanently as safety device inspector to see that no guards are unnecessarily removed from place, and that they are immediately replaced if taken down on account of repairs to machinery. Signs and placards have proved to be very effective in calling attention to dangerous places. A large red disc with the word "DANGER" is placed in all departments which have

been reported by the inspection committee to be in need of guards or repairs and is not removed until the dangerous condition has been satisfactorily attended to. Safety mottoes and posters are placed in conspicuous places, and on every pay day when a man receives his pay envelope the first thing he sees is a safety motto. These mottoes are changed every pay day. It is to be noted that signs calling attention to danger are overlooked by employes after they become accustomed to reading them, just as dangerous conditions are treated with contempt after men have become familiar with them. It is only by additional posting of new signs that accident prevention can be accomplished.

To arouse a spirit of competition between departments in safety work, a statement is published every three months showing the number of accidents in each department both avoidable and unavoidable. The departments are arranged in the order of the number of accidents, the bottom of the list being the most honorable position.

A Comprehensive Committee System

The committee system of handling safety work having proved itself successful, it is now proposed to reorganize along more comprehensive lines. With this in view a plan, which has already received the approval of the president of the company, has been drawn up, which calls for the formation of the following permanent committees:

First.—A central committee, to be composed of the president of the company, the general works manager, the superintendent of the South Milwaukee plant, and the superintendent of the Evansville plant.

Second.—A works committee, to be composed of five of the general foremen and the safety engineer.

Third.—Several shop committees are to be appointed. Each department, of which there are 24 in all, will have a committee with the department foreman as chairman and two or three intelligent workmen as members.

The duty of the central committee is to pass upon all matters pertaining to safety, which have been recommended by the works committee.

The duty of the works committee will consist of meeting once a month to go over the monthly inspection sheets, discuss any serious accidents which have occurred, go over reports from the shop committees, and to make recommendations to the central committee.

Each shop committee will make weekly inspection of its department and the chairman will be required to make a written report, weekly, concerning the conditions of his department relative to guards, sanitary conditions, safe operation methods, etc. Whenever a serious accident occurs, the department committee will fully investigate the cause and make recommendations to obviate a recurrence of the trouble.

It is proposed to award prizes each month to the department having the best safety record. These prizes will consist of cigars, tobacco pouches, drinking cups, etc., and each man in the department will get one. Of course, some departments are more hazardous than others, and this will be provided for by allowing certain handicaps.

The company has found it imperative to hire only men free from physical defects. This necessitates examination by a competent physician of every man employed. More than 12 per cent of those examined have been rejected.

Before closing, it should be noted that the company has found the cost of personal injuries considerably less under the compensation act, than under the old system of carrying liability insurance. Moreover, disputes as to settlement are almost entirely eliminated, and when they do occur, it is not necessary to go through an expensive law suit to settle them. A hearing before the Commission settles the trouble. It is not necessary to employ a lawyer and if one be employed, the law has fixed his fee at 10 per cent of the award for a maximum charge.

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In this connection the following from the editorials of the *Saturday Evening Post* of Aug. 1, 1914, is of interest:

"Experts on the subject say that the Workmen's Compensation Act which went into effect in the state of New York on July 1, 1914, is the most liberal yet adopted in this country. When the act went into effect more than fifty thousand employers were affected and it was calculated that the annual cost would be at least twenty-five millions of dollars per year. That is a large sum and the critics made much of it. How much the barbarous old contingent fee, damage suit, flip a quarter style of compensating for industrial accidents cost employers nobody seems to know. It was certainly many millions of dollars per year and certainly a great part of whatever it cost was utterly wasted in lawyers' fees and court expenses. The last census says that manufacturing in the state of New York employs more than a million men and turns out a yearly value exceeding three and a third billion dollars. The twenty-five million dollars which it is estimated the new law will cost employers, therefore, amounts to less than 1 per cent of the value of the annual product."

Sanitation and Safety First Applied to the Brass Industry

By F. Moerl, Chicago.

Few topics have commanded the attention of those engaged in the manufacture of brass products for the last two or three years, more than that of sanitation and safety first, and it is only fitting that this subject should receive due consideration.

These days nearly every issue of our various trade journals, contains articles treating on the subject, enlightening us as to what has been and what can be done in improving present conditions.

The laws written on the statute books of the different states, as well as the compliance therewith and the voluntary application of safety devices and adoption of sanitary measures on the part of the shop managements, are for the purpose of improving the welfare and conditions of working men.

And while it may appear that great sums of money are spent these days in this safety work with no direct cash returns, in carefully scrutinizing results, we will find it not alone one of humanity, but also one of economy. For instance, a man working on a certain machine is injured and incapacitated for a week or two, which may require the machine to stand idle, or as is usually the case, the injured man is replaced temporarily by one not so familiar with that particular job. Consequently the output will not come up to the usual quality or quantity, which means a financial loss to the firm. How much better a man can work in a clean, well-lighted and well ventilated foundry or finishing shop, than in one presenting opposite conditions, is well known.

At the Buffalo convention of the American Institute of Metals, in 1912, Dr. Charles L. Parsons, representing the United States Government Bureau of Mines, brought up the subject of health conditions in brass foundries, and the discussion which

followed demonstrated that many of those present were keenly interested in this problem of conserving human energy, and that several of the industries represented had already installed shower baths and other sanitary equipment.

July 1, 1911, the occupational disease act became effective in the State of Illinois, and at first the attitude of many of both employers and employes, was more or less hostile through-

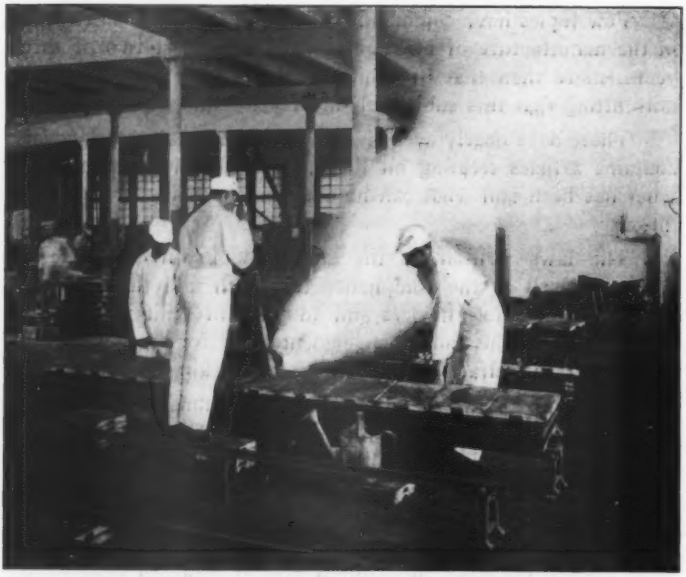

FIG. 1—POURING BRASS AT THE PULLMAN WORKS.—NOTE THAT THE MEN ARE CLOTHED IN WHITE

out the state. Some employers, considering it a new-fangled fad, reluctantly complied with provisions of the law and then only to such extent as to be within its absolute requirements. Others willingly and cheerfully installed the necessary equipment, and even went beyond that which was expected of them in providing safety and sanitary measures.

On the other hand, the men did not unanimously welcome the law as one made primarily for their welfare, and displayed

more or less antagonism. They regarded the compulsory compliance on their part as an encroachment upon their personal liberties. At the Pullman Co.'s plant in Pullman, these conditions have been practically overcome, and what is now commonly known as the "Safety First" movement, is being more and more advanced by both management and employes.

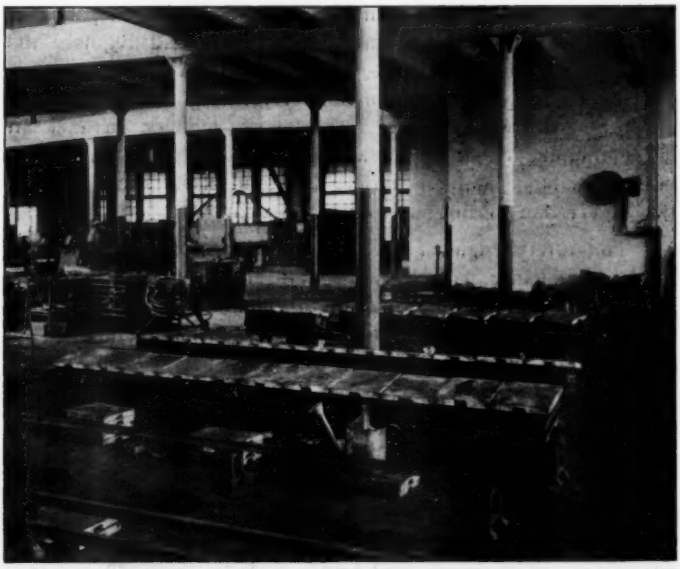

FIG. 2—THE SAME ROOM AS THAT SHOWN IN FIG. 1 THIRTY SECONDS AFTER POURING

In patent medicine advertisements we sometimes see an illustration of a person before and after using the highly recommended 'cure-all-and-heal-over', and in recalling the sights while witnessing the earlier medical examinations, and again those following a month or two later, we were vividly reminded of these ads. This refers to general personal appearance and cleanliness, particularly the teeth. The bad condition of the latter was astounding, and nearly every other examination resulted in the doctor's order, "Clean your teeth".

As my duties require the supervision of the manufacture of trimmings for approximately 2,000 cars a year, taking in not only Pullman, but also various contract cars for the different railroads throughout the country, my observations of the Safety work are practically limited to the brass department, and outside of that, I can speak only in a general way.

That portion of the work directly affected by the Illinois occupational disease act, is in charge of the safety department chief clerk, and it is his duty to supervise and regulate the medical examinations, baths, changing of overalls, jumpers, towels, etc., making proper entries on forms gotten up for that purpose. Molders, grinders, coremakers, melters, in fact all brass foundry employes, including the office force, polishers, buffers, platers, painters, glaziers and sand blasters, come under the supervision of this end of the department.

The safety engineer investigates and recommends relative to the compliance with Federal, state and city laws and ordinances regarding matters of sanitation, buildings and prevention of accidents. This end of the safety department takes in the entire plant.

Before we can put a man to work at any of the named occupations, he must first undergo a medical examination, made by the company's physician, who reports on a regular form as to the applicant's health. When the application has been approved, the man may be put to work, but before commencing, the safety department furnishes him with a pair of white overalls and jumper, towels, nail brush, and, if necessary, goggles, respirator, rubber gloves or rubber apron. The goggles are supplied to grinders; rubber gloves and respirators to sand blasters. A proper record is kept of this transaction, and when leaving the company's service these articles must be returned to the safety department, where they are properly sterilized. Suitable shower baths are installed, and it becomes obligatory on the man's part to take a shower bath at least once each week, a certain time being allotted each department or part thereof for that purpose.

One-half hour is allowed by the management for each man every week, and no deduction of time is made while taking the

bath. Once, and in some cases, twice every week, he turns in his soiled overalls and jumper, and is furnished a freshly laundered set. The towels are also frequently changed the same way, and the respirators cleaned and sterilized at regular intervals.

Each employe coming under the regulations of the safety department, is allotted a two-compartment steel locker, equipped

FIG. 3—SAFETY BULLETIN AT THE PULLMAN WORKS

with a small mirror, proper shelving and suitable coat and hat hooks. Locks are fitted to individual keys; the keys are fastened to a key ring, together with the employes' gate house brass check. The lockers are divided into an upper and lower compartment; the upper for the street clothes, and the lower for the shop wearing apparel, and are so located in the different washrooms as to allow sufficient room for changing from street to shop clothes, or vice versa. The wash-rooms are

equipped with long, and in some cases, individual wash-basins. The large ones have a number of faucets with running water, the latter being properly mixed to a suitable temperature in an adjacent large tank. Liquid soap containers are placed at regular intervals. Ten minutes prior to quitting time, these wash-rooms are opened to the men to wash in and change clothes,

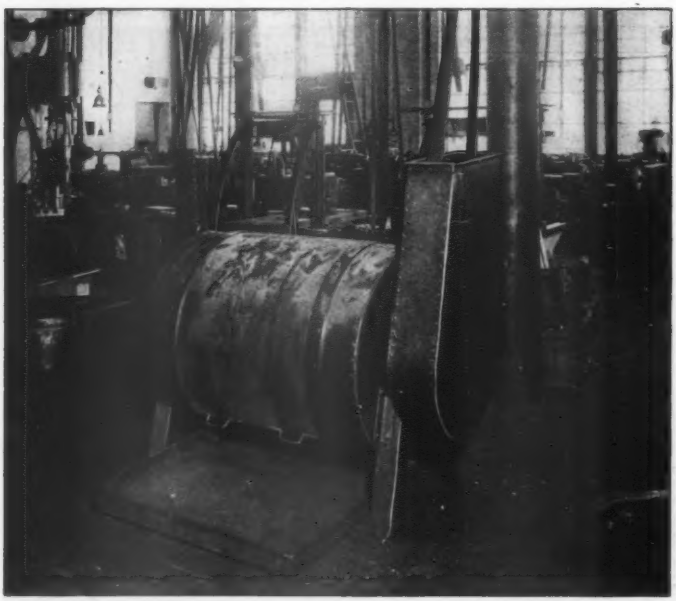

FIG. 4—TUMBLER PROVIDED WITH BELT GUARDS

and by the time the whistle blows, they are all cleaned up, and in leaving the works many might well be taken as belonging to the office force.

Every employe in the brass foundry and finishing departments must undergo a medical examination once every month, and if found affected with plumbism, or any disease peculiar to the trade at which he is working, he is most closely scrutinized with a view of overcoming the cause of the ailment, which usu-

ally results in the correction of some slight improper practice, and the consequent disappearance of symptoms. In the more severe cases and those where no correction can be made, other employment is found, but even then the case is kept under the doctor's surveillance until complete recovery.

One of the great problems in the brass foundry and brass finishing shop, is that of ventilation. While the construction of some of the older buildings is such as to necessitate artificial

FIG. 5—FIRST AID CABINET IN WASHROOM

means of removing fumes and foul air, yet buildings of more modern types are, or should be, so designed as to insure natural ventilation by providing sufficient windows and sky-lights, which can be easily and quickly opened and closed. In summer-time this will work out without any great difficulties, but in cold weather we find that the men object more or less to the opening of the windows, and some would rather inhale the metal fumes. In such cases we found that the factory inspector

FIG. 6—SAND BLASTING UNDER A HOOD

insisted upon opening up everything during pouring time. In the accompanying illustrations will be found reproductions of

FIG. 7—SAFETY BULLETIN AND SUGGESTION BOX

of two photographs. One picture was taken while pouring, and the other was snapped in the same position as soon as the smoke had cleared away, which was only thirty seconds.

FIG. 8—FIRST AID ROOM

The floors in the brass foundry should be kept moist at all times, and one of the laborers delegated to liberally use the sprinkling can. Under no circumstances should any one be allowed to eat lunch in the foundry, polishing or plating rooms, and suitable places should be provided for that purpose. The Pullman car works was one of the first shops to meet all and even went beyond the requirements of the occupational disease act, and the management at all times is willing to consider any new safe-guarding device, or suggestions of health measures.

In order to better demonstrate some of the results of our activities along these lines, we present a few reflected pictures, all of which were taken at our works.

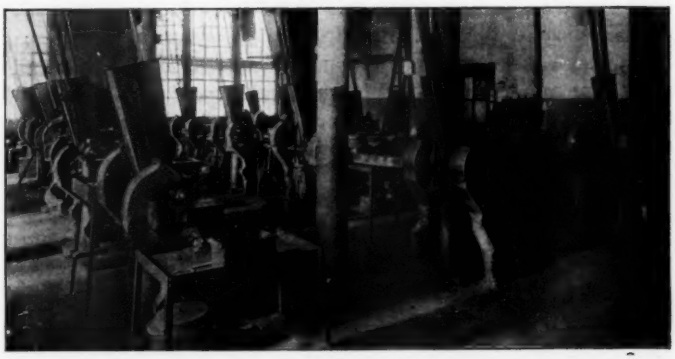

FIG. 9—POLISHING WHEELS PROVIDED WITH DUST EXHAUST HOODS

The emery wheel exhaust heads and guards were designed and made in our own plant. The exhaust heads are made of ⅛-inch sheet iron, and the guard bands of ¼-inch boiler plate, assembled by oxy-acetyline welding. The whole head is arranged to slide, so as to take up for the wear of the wheel. The lower portion of guard front can be adjusted so as to close off that part of wheel not in use. The lid for removing the wheel is hinged, and when closed is fastened by a catch, as well as a bolt and nut, serving as stress members in case the wheel bursts.

Our shower baths are equipped with a mixing tank, which is supplied with hot and cold water, regulating it to a suitable temperature. They are grouped in sets of seven, each again sub-divided by canvas curtains, for the individual bath. Vapors are drawn out by large natural draft ventilators, placed in ceiling or side wall.

We have 28 "First Aid" cabinets placed around the different departments of the works, and about 70 men are trained to do first aid work. The first surgical attention is received in the "first aid" room, and in case of fracture the X-ray apparatus is used for determining the mode of procedure. Photographs are taken of all fractures. While we term it the "first aid" room, the equipment and facilities are sufficient for handling any minor or more serious operations.

To clear a dipping room from the obnoxious acid fumes is a difficult task. After trying out various schemes and ventilating systems, we found an 18-inch wall type fan run at 1,700 revolutions per minute direct connected to a motor, the most effective. The motor must be either encased or the fan shaft extended into the next room and there connected.

Guards completely enclose the tumbling barrels and also the belts up to a man's height. The belt guard is arranged to open easily and quickly in case of belt repairs. The portion of guard over the tumbling barrel proper can be opened similar to the roll top of a desk.

Progress in the Safety Movement and the Latest Aids to Good Safety Work

By Arthur T. Morey, Granite City, Ill.

Only recently we needed to be aroused to the accident situation. We had to be shocked into action by being made to realize that there was a menace in our midst more deadly and destructive to lives and property than the ravages of war. That stage of the situation is passing and the national consciousness has been finally awakened to partially know that there is an accident problem, is earnest to see it solved, and there is a widespread movement to that end.

The public however does not yet fully grasp the situation nor see that accident prevention really very largely concerns a condition of thought in the public consciousness itself. It does not yet comprehend that accidents are not so much the product of occasional aberrations as they are due to the commonplace thoughtlessness in the daily life and customs of the people. The public still looks off at the factories and railroads and powder plants, and considers abnormal conditions as the causes of accidents, instead of having the self-examination to see them only as the results of common habits of carelessness.

Any accident claiming one victim by careless haste is not yet seen to carry as great instruction as the big disaster claiming many victims, and yet the greater disaster does not usually differ in cause from the smaller accident. It seems to need some great catastrophe to focus public attention on conditions that are constantly causing isolated accidents, whose aggregate loss is far greater. The public is impressed with the accident which exacts the Titanic toll, but does not have that self-analysis to note the subtle mental causes of which the Titanic loss was only an effect.

For this reason the small as well as the great accidents do not have the educational value that they should, and terrible repetitions assail us. The one-victim accident or the near-accident can and should be as instructive to us as the Iroquois fire or Empress of Ireland disaster.

The Desire for Haste a Racial Characteristic

The desire for haste in the Titanic case was not greatly different from the dangerous risk that we take when we hop a street car, or the taxi's risk to please a passenger. Again I say for emphasis that these big accidents are not sporadic happenings under unusual circumstances, but come largely from racial habits of careless thought, and the man who causes a great catastrophe is anathematized for manifesting a racial characteristic. The flower pot on the window sill; the convenient loaded revolver and poison bottle; the kerosene to light a fire; taking a chance with gasoline; workmen not using safeguards; taking a risk with inadequate exits in a theatre; rocking the row-boat; dashing in front of a train or an automobile; standing around splashing metal in a foundry without goggles; speeding past dangerous places in an automobile or speeding among icebergs in a ship are indications of public habits of thought that are all the same in kind, but are, however, judged as being different by a not very discerning public.

The Constructive Value of Safety Work

One of the greatest values of the Safety First movement is to reach these causes of accidents in the consciousness of all the people, the workmen, the children, the parents and the public generally. On this basis safety work has a very valuable constructive force in making our people more thoughtful and careful and alert, and on this account is one of the greatest values brought to us in modern times.

Safety work also is bringing great aid to the advance of the brotherhood-of-man idea. No other movement has served better to bring men together on a plane of mutual understanding, appreciation and co-operation than the safety movement. It has made workmen and management kin; has

planted good-fellowship and a get-together spirit that means much and will mean more to the industries and to the country. We too much see and magnify evil in each other and too much distrust each other; but when we can meet on a common ground and see and appreciate the good in each other and understand each other, the world is made truer and better. In some respects these things make the safety movement one of the greatest movements of all time.

The gratifying part of the situation is that good safety work is actually giving very fine results in cutting down accidents and in making better and more thoughtful workmen. One of the most pleasing and interesting phases of the situation is that good safety work is not only agreeably humane in its lessening of suffering and loss to the workmen and their families, but being a study of the right way to do things, is a great aid to shop efficiency and economy, and thus the safety movement is being helped from all angles.

Accidents Decreased in Number

The first six months in 1914 show a remarkable decrease of accidents in our plant as compared with the first six months when we commenced our work and with the first six months of 1913. In the first mentioned six months our compensation loss was $11,757.90; in the first six months of 1914 it was about $3,290.48 or a decrease of some 72 per cent. In the first six months of 1913 we had 499 lost time cases from accidents. In the first six months of 1914 we had 246 lost time cases, a reduction of about 50 per cent. These reductions were in the face of an increase of some 20 per cent in the number of men employed. Mechanical safeguarding will proceed to a practical efficiency, and the larger part, the education in habits of care, will complete the work, until we discover it entirely unnecessary to have these self-inflicted losses on the community.

I will also say without hesitation that we feel a fair and wise Workmen's Compensation Law, is a great incentive and aid to good safety work, and a good thing for both workmen and employers.

What success we have had in the Commonwealth Steel Co., has come from seeing that good safety work has so many efficiency, humane, good-will and economical benefits, that we saw we should not hesitate to spend any amount of money nor to go to any trouble necessary to stop accidents.

Organization and Education Best Safety Help

As mechanical safeguarding stops only the smaller part of accidents, we are doing our best to stop the rest of them by organizing and educating the men to get them into the constructively beneficial safety habit. We have a high-class mechanical engineer as our safety engineer; a central safety committee over the whole plant composed of our strongest plant officials, which co-operates with the safety department upon the big problems, and binds all into the work. Shop safety committees in each department watch things and make recommendations. We require monthly reports from all foremen and sub-foremen on the conditions under them on forms provided. We have gotten out a book of helpful safety rules, and think it none too much to expect to eventually reach the goal of our slogan —"No Accidents."

Co-Operation and Good Will Necessary

Having the men with us and having a good spirit in the organization are the great things. Without having the cordial co-operation of the men the best safety work cannot be done. That cordial co-operation can only be obtained by just and fair dealing in all other relations, and the earnest desire on the part of the management to treat the workmen as men and with every consideration, surrounding them with all proper and decent environments. We have a good lunch room for all the men, a good club house, a dining room for get-together luncheons of officials, night school, Fellowship Club, are establishing a refrigerated pure drinking water system throughout the plant, are shortly to provide locker, washing and shower bath accommodations for every man; we have some flowers and grass plots, and with it all we are avoiding all paternalism. We are simply trying to make ours a decent and attractive

plant, and we feel that these better conditions are *earned* by the men and are not *given* to them, for they are part of the fruit of the men's toil. We are establishing an efficiency card record for all men who have been employed one year or longer, so their merit may be known and rewarded, and we are now having physical examinations made of all new men, from which will be developed many helps to the men.

"Fellowship" and not "Welfare" Work

We have not used the word "welfare" in our work, feeling that it smatters more or less of paternalism, but we have called ours fellowship work, thinking that the word fellowship is a truer and kinder term.

I will quote a few scattering extracts from our president's prefatory instructions in our safety rules book, to indicate something of the good feeling and spirit of our organization, and I wish to put special stress on the fact that good feeling and good spirit are essentials to the best safety and fellowship work:

"It has been the policy of our company, in its relations with its customers and in the relations between management and men, to do unto others as we would have them justly do unto us. On no other basis can we succeed externally with the public as a company, or internally as an organization. It is apparent that in no part of our work is this spirit more necessary than in safety work.

"Safety First shall be our policy, for if this were not so, we would value money above the lives, limbs and health of our workmen, for every haste and so-called economy that the policy of Safety First would seem to interfere with, is measurable in dollars and cents. We older men must set the example to our Commonwealth Fellowship Club boys and other young men that money to be enjoyed, must be well earned and be clean of all selfish cost. We should find, however, that safety work being a study of the right and orderly way to do things, will increase efficiency and aid economy.

* * * "Such a large majority of accidents are due to carelessness, that we will have to accept the larger sense of being our brother's keeper and try to protect him from his own carelessness.

* * * "Let us then, and without timidity, set the mark for ourselves that we eliminate all accidents and set our faces resolutely to that end.

"And one other very important thing we must bear in mind: In this safety work we must not improperly use fear, for such a campaign might result in lessening efficiency, and workmen will be afraid to do what they properly ought to do. We should fear to be careless, but we should work more from the standpoint of avoiding accidents by becoming more carefully efficient, then all are uplifted and made better workmen as well as safeguarded. Fear is negative, carefulness is constructive. On this basis safety work should improve operating conditions, for carefulness and efficiency go hand in hand.

"When carefulness and efficiency become fixed habits, accidents will not trouble us."

A Clearing House of Safety Helps

I can gratefully say that safety men everywhere have shown a very fine and unselfish spirit in helping along the cause of safety. A good safety man apparently cannot do too much or go too far in helping some other individual or company to have the advantage of all that he himself has learned on the subject. A beautiful spirit has pervaded the work throughout the whole country.

In this same spirit of helpfulness, probably the greatest aid that has come to safety work has been the natural evolution of the National Council for Industrial Safety, which has been formed for the sole purpose of providing a clearing house of information and experience as to safeguards and methods to help along the cause. The fees charged members are nominal, and the weekly letters containing splendid posters for shop bulletin boards, and other safety helps, have been invaluable to us in our work. Most safety problems can be answered out of the Council's files, and any information not at hand will be obtained for the enquiring member from all the best safety men in the country endeavoring to help on the problem. It being an unselfish, non-profit organization, I do not hesitate to commend its activities to all the members of the American Foundrymen's Association, for the Council can be a great and invaluable assistance in every phase of your safety work, thus

saving much costly experimentation and putting at your disposal, for a very nominal membership fee, the best experience and thought of the country on the subject, and bringing to each of us the expert advice and assistance on every peculiar and difficult problem. It is of special aid to the small shop which cannot afford an expensive safety department, bringing to it the value and aid of the most expert safety experience obtainable. The council's main office is in Chicago, in the New Continental Commercial National Bank building, and there are local councils throughout the country where members of the council have organized for local purposes of round table discussions and self helps.

I thought it would be helpful to the association to see some stereopticon slides of safeguards that we have worked out at the Commonwealth Steel Co., and which we are well pleased to contribute to the cause of "Safety First." They deal with problems that have been a serious menace to life and limb, and we feel they have, in many cases, entirely eliminated chances for specific accidents in our foundry. If they contain any value to you, it will greatly please us, and any other information we can give will be cheerfully furnished to anyone.

The list of slides follows:

Automatic sand bucket bale-guard.
Jib crane practice, showing handles on links, steel beams, steel notches, etc.
Howe rip saw guard.
Howe jointer guard.
Grab bucket handles to save hands and feet.
Suggestion boxes.
The value of good order in the foundry.
Eight hundred and fifty foot lamp trimmers' walk in foundry.
Overhead crane walks.
Guarded swing saw guard.
Collapsible horizontal drill guard.
Access platforms for crane cages.
Swinging emery wheel hood.
Dunkle foot guard for railroad guard rails and frogs.
Core ovens arranged to keep smoke and fumes out of workroom.
Shield on charging machine.
Dispensary.
Frostless fire extinguisher box.
Court showing grass and flowers.
Workmen's locker room.
Workmen's restaurant.
Club building.

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SAFETY FIRST

By F. W. Reidenbach, Rochester, N. Y.

When I was asked to prepare a short paper for this Convention on the subject of "How to Avoid Accidents in Small Foundries, or Health and Safety of Employees" and one that would create a discussion, the thought occurred to me that "Safety First" would be a good title, being so well known throughout the entire country. After making a thorough examination of a large number of casualties, the main and most vital causes are summed up under two headings, lack of proper education and the use of intoxicating liquors.

Then we must consider the first portion of this paper: "How to Avoid Accidents". And as order is Heaven's first law, so "a place for everything and everything in its place" seems to me to be the one and greatest factor in the prevention of accidents.

The lack of proper education is perhaps largely the cause of many of the small casualties. To speak along generalities would be to unjustly charge some men, (and I hope they are in the minority), with an absence of brains. But after all is said, is not this lack of brains, the very thing that is directly or indirectly the cause of our troubles?

If such a condition could arise whereby any boy or man who does not meet with the ordinary requirements of at least a common school education be barred from employment in foundries or shops where machinery and furnaces are in operation, in a few years it would revolutionize the whole foundry situation with regard to the safe operation of all plants. A good recommendation to put into force is this one copied from the DuPont Powder Co's resolutions for the New Year:

Learn and obey rules and instructions.
Never take chances.
Never take short cuts by the path of danger.
Think before you act.
Be watchful for your safety and that of your fellow employees.

Be neat, cleanly and efficient, not only in personal habits, but in work and care of tools, apparatus or buildings.

Report dangerous conditions or dangerous practices.

Keep your temper when handling tools or men.

Extend a helping hand and a few words of advice to the newcomer, to the foreigner or the man who does not understand.

If this can be carried into effect, an ideal plant will be maintained and all will enjoy happiness and serenity that serves to perpetuate unity of employer and employee, and its good effect upon all conditions, both moral and financial, will accomplish much.

There should be no conflict between the employer and the employe upon the questions that have been before the public for a long time. If viewed in the right light, you will find that the employer and employe are yoke fellows and when a man wishes to rise to the full expectation of his ambitions, he must consider his lot as one of yokefellow. "I will" has achieved more victories than "I can't".

The sale and consumption of alcoholic liquors is the most vital of all causes of deficiency in our men. Here it will be necessary to use quotations from men of authority and the very first is our own Thos. D. West of Cleveland.

"One immediate result of the nation-wide prohibition movement is the recognition being accorded liquor as a chief factor of industrial inefficiency. As a consequence, Thos. D. West, manager of the West Steel Foundry Co., of Cleveland, O., voices the business view of the question in this statement: "This inconsistent outwitting of justice, common sense and humanity (saloon license) supported by laws is responsible for many of the 2,000,000 injuries and 35,000 deaths that occur annually in the United States today attributed to industrial causes". This alone is strong enough evidence to convince anyone of the employers of men that drinking habits are detrimental to good workmanship.

But here is another and more convincing argument: "Under local prohibition there has been a decrease of 54 per cent in accidents in the big steel mills of Coatesville, Pa., and a decrease of 75 per cent in applications for aid in just six months' time, according to the testimony of the vice president,

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Chas. L. Huston. Furthermore, the decrease in absences from work on Mondays or days following pay days is 80 per cent."

Now the attitude of our large enterprises is being directed against this one great cause of inefficiency. Let me offer just a few more of these vital and direct changes. To quote from a newspaper:

"Kittanning, Pa., Feb. 25.—Employees of the American Steel & Wire Co., here and in Leechburg, Pa., where the company has large plants, were today notified to withdraw at once from fraternal organizations that conduct clubs. Officials in giving the order declared that the sale of liquor in such clubs impaired the efficiency of working forces in the mills."

To Encourage Total Abstinence in Steel Mills

"Pittsburgh, April 1.—A new rule has just been posted by the Carnegie Steel Co., in all its plants in the Pittsburgh district as follows: 'To the employees of the Carnegie Steel Co: Hereafter all promotions of any character whatever will be made from the ranks of those who do not indulge in intoxicating liquors of any kind and are known to be abstainers or teetotalers in all the meaning that these words imply. Foremen of the various departments are instructed to enforce this rule.' Signed, A. C. Dinkey, President. This order was posted at the instance of E. H. Gary, chairman of the U. S. Steel Corporation, who has issued a statement to the effect that the Corporation is determined to advance only sober men and those interested in the move to drive intoxicating liquors out of the big steel plants, as many accidents are said to have been due to intoxicated workmen. This order will apply to all of the subsidiary companies of the Steel Corporation."

The Standard Oil Co. has adopted the same course as the steel companies and many other institutions of production are of the same opinion.

Safety in health calls for a well-lighted and thoroughly ventilated foundry, and especially so when any great amount of yellow brass castings are in course of manufacture. Keep the air as pure as possible. If you have no natural means of

ventilation, use a suction fan, the increased amount of work obtained will more than justify the installation and cost of operation. It pays both employer and employe.

Next comes cleanliness. Have a wash room. Quoting from the Scripture, "Cleanliness is next to Godliness." So cleanliness is essential to good work. Soap is the greatest product of the centuries when used. When a man is afraid of a small piece of soap and a little water, you are justified in filling his place with one who is not. This, with an abundant supply of good water is all that is required of any foundry to give the employee the foundation of real health. All the rest lies with the employee.

So what is the conclusion? But few things remain charged against our industrial advancement of efficiency, other than the lack of proper education and evil habits. So the following recommendations are submitted for discussion:

First, to bring about the conditions set forth in this paper, all men shall possess at least a common school education to be employed in any ordinary capacity in foundries and only men of higher education to occupy positions of trust and responsibility, always giving a man a chance to rise from the ranks.

Second, under no circumstances whatever shall any man either in a minor position or an executive one be considered who is not an absolutely total abstainer from all kinds of liquors.

XUM

Safety in Connection with Grinding Wheels

By R. G. Williams, Worcester, Mass.

Your committee has requested that I talk to you on the subject of safety in connection with grinding wheels, and as an introduction, an account of a conversation which took place between a man who has devoted considerable time to this subject, and the superintendent of a foundry, I hope will present this matter in an acceptable manner.

The Smith & Jones Foundry, of Centerville, had a 20 x 2-inch grinding wheel break and luckily no one was hurt. The wheel was unguarded and according to the operator, he had just finished grinding a casting and was on his way for another when he heard a loud report, turned around, and found the wheel had burst. Smith & Jones wrote the manufacturers of the wheel requesting them to send a man to investigate the breakage, and a Mr. Duncan was sent to Centerville. The superintendent of the foundry, Mr. Carson, made a trip through the foundry with Mr. Duncan and the following conversation took place.

Mr. Carson—"I suppose one of these Hunkies will get hit some day and then we will have to put guards on our grinders. The laws in this country are getting so strict that we will have to box in all our machinery before we get through."

Mr. Duncan—"Yes, the laws are pretty strict if looked at from some points of view, but it is better to be safe than sorry. I know of an instance which happened in a certain foundry which illustrates this point. The swing frame grinding machines were not hooded, although they could have been without interfering with the work, and one day while the superintendent was taking a friend through the plant, an accident occurred which broke a wheel. A piece of the wheel flew 50 or 60 feet across the room and hit the superintendent

on the head, with the result that he spent four months in the hospital. The fact that the machines should have been hooded had been brought to his attention, but he only replied that he had been running those machines for five or six years without anything happening, and he guessed he'd let well enough alone."

Mr. Carson—"Well, in regard to the wheel that burst here the other day—this is the floor stand it was used on and you can see from the class of the work that small castings like that couldn't have damaged the wheel very much. The broken pieces of the wheel are over there in the corner and if you want to, you can look at them. I think the wheel must have had a flaw in it, or it wouldn't have broken so easily."

Mr. Duncan—"I am very glad that you saved the pieces of the wheel. Here is some evidence which is pretty conclusive as to what caused the breakage. Look at this circular groove where the structure of the wheel is crushed and where metal has been forced into the pores of the wheel. That indicates clearly that while the wheel was running, something caught between the side of the wheel and the machine, with sufficient wedge action to break the wheel."

Mr. Carson—"I hadn't noticed that mark before and now you call my attention to it, it certainly does look as if something had wedged the wheel on the side. Come to think of it, the same day this accident occurred, I was going past that machine and noticed the rest was quite a distance away from the wheel. Without a doubt that was the way the accident occurred, and now that you have brought out this point, suppose we look at our grinding machines and see if you have any recommendations as to how we can prevent grinding wheel breakages."

Mr. Duncan—"I will be very glad indeed to look over your machines and will help you all I can."

Mr. Carson—"While we are here, just run over for me the known causes for grinding wheel accidents and what you consider to be the best way of preventing them."

XUM

Mr. Duncan—"Well, besides a wheel receiving a blow on the side while running or during the noon hour, or something becoming wedged between the side of the wheel and on the machine, a breakage can be due to a number of causes. The mounting of the wheel is mighty important. The flanges should always be of the same size, and they should also be relieved; that is, they should be recessed out from the center, about 1/16-inch deep, for a distance which leaves a flat bearing surface near the rim of approximately 1/16 the diameter of the flange. A compressible washer of blotting paper or rubber, slightly larger than the flanges, should be used between the flanges and the wheel.

"An accident occurring in a certain foundry a few years ago illustrates the points I have just mentioned. The operator had a piece to grind of such shape that the outside flange interfered. Without permission from anyone, he took off the ouside flange, put a small rough forged washer next the wheel, then the flange and nut. The machine was without protection hoods and when the man started to work on the wheel, it broke and he was killed.

"The inner flange should either be keyed or shrunk on the spindle. Accidents have been caused by heavy pieces of work rubbing against a loose inside flange and the brake action produced was great enough to cause the nut to crawl, with the result that enough pressure was set up by the flanges to crush the wheel. Flanges should also bear evenly on the wheel, in other words, there should be no dirt between the flanges and the wheels. Sometimes, a wheel will be broken because the hole in the wheel and the spindle are too tight a fit. The man mounting the wheel will force it on the spindle with the result that it does not line up true when the flanges are brought against it. When the machine is started, the wheel will run badly out of truth. It is not necessary to draw the nut up very tight; only enough to firmly grip the wheel between the flanges. Cases are known where a wheel has been crushed due to excessive tightening of the nut. It has been calculated that on an 1½-inch machine with 8-inch flanges, a man with a 2 foot wrench can easily exert a crushing pressure between wheel and flanges of 3,600 pounds or over 1½ tons.

"The condition of the grinding machine is also mighty important. If the bearings are allowed to become badly worn, there will be excessive vibration, causing the wheel to run badly out of balance. If the bearings are not kept properly oiled, the spindles will run hot and the heat will be conducted to the lead bushing in the grinding wheel, with the result that breakage may occur due to the expansion of the bushing.

"Of course the speed of the wheel is important, and the speed recommended by the wheel manufacturer absolutely should not be exceeded in any instance. Wheel manufacturers are careful to very thoroughly test the wheels for safety before shipment, at a speed which gives the wheels a factor of safety of between three and four; so that under ordinary conditions, wheels will safely stand an amount of overspeed represented by the testing speed. However, wheels may get damaged after they have been tested, and it is not possible to tell whether a wheel is damaged or not by looking at it. Tapping a wheel a light blow with a small hammer will usually tell if it is damaged, for if the wheel is perfect it will give out a clear ring, but if it is cracked it will have a dead sound. When there are cone pulleys on a machine, sometimes a loose belt will automatically shift to the small cone pulley, and cause the wheel to run faster than it should. A belt locking device is a good thing to use on a machine which has cone pulleys."

Mr. Carson—"I am afraid I can't remember all you've said. Is it in a book or magazine that I could get hold of?"

Mr. Duncan—"Yes, a number of articles have been published. The National Machine Tool Builders Association has a report in the proceedings of its last convention, which was made by a special committee. The National Founders' Association has also covered this subject in one of its safety bulletins and the Norton Co. has had two booklets issued."

Mr. Carson—"I guess I will have to get some of that literature for our files. In traveling around, do you find goggles used?"

Mr. Duncan—"Almost entirely."

Mr. Carson—"Well every man in my cleaning room will wear them or get out. We used to have fellows going up

town every day to the doctors to have things taken out of their eyes and since we've been using goggles, we haven't had any trouble at all.

"Another thing I meant to ask you. Do you consider a hooded grinding wheel dresser a good thing?"

Mr. Duncan—"Yes. Most revolving cutters are made of chilled iron and break very easily. A hood on a dresser will catch most of the broken pieces."

Mr. Carson—"Well, I am much obliged to you for your information and if I remember all you have told me, we ought to reduce our grinding wheel accidents to the lowest possible number."

Tests of Safety Flanges

About a year ago, the question was agitated as to whether the so-called safety shaped method of guarding grinding wheels afforded as much protection to an operator as the use of straight wheels in connection with a hood of proper design. In order to obtain reliable data on this question, the research laboratories of the Norton Co. conducted a series of breaking tests wherein grinding wheels were broken while running at actual operating speeds. The tests were of two kinds.

First, 16-inch diameter by 2-inch thick Alundum vitrified wheels with parallel sides, were broken while surrounded with hoods of rigid design.

Second, 24-inch by 2½-inch thick Alundum vitrified wheels, tapered ¾-inch per foot were broken while mounted between steel flanges of the same taper. The flanges were the following diameters: 12, 14, 16, 18 and 20 inches. The test with the flanges were conducted by breaking wheels in the smallest flanges at the beginning of the series, and then increasing the size of the flanges until with those 20 inches in diameter, only 2 inches of the wheel projected between the area of the flange.

The method used for breaking the wheels in the hood test was by dropping a steel wedge between the side of the wheel and the work rest on the machine. The method used for breaking wheels in the flange test was by striking the wheels

a severe blow with a cast iron weight of 130 pounds. A wheel speed of 6,000 surface feet per minute was used for all tests. A report of these tests has been covered in a booklet form, and many of you are doubtless familiar with the results obtained. It would not, perhaps, be out of place to briefly review the general observations, and the conclusions reached.

Hoods Are Safe

In none of the hood tests did the pieces of wheel leave the wheel in a way that could have caused damage. The tests show conclusively that a well-designed protection hood, made of the right material and properly adjusted, affords ample protection for straight sided wheels even when they are mounted between standard straight relieved flanges, one-half the diameter of the wheel.

It is possible to break pieces from a wheel by a severe blow when there are only 2 inches of the wheel projecting beyond the flanges. With tapered flanges, no matter how little the wheel projects beyond the flanges, the operator has no protection from injury in case a piece of the wheel breaks off outside the flange; whereas, with a hood protection is almost absolute.

The tests conducted conclusively proved that protection hoods provide greater safety than do safety flanges. The protection offered by any given taper decreases with decreased diameter of wheel. To provide equal safety on all sizes of wheels would require, therefore, a graduated difference in taper. A hood with adjustable tongue furnishes equal protection for a wide range in the diameter of wheels. A hood which is adjustable to the base of the grinding machine also serves the same purpose.

Second to safety, the cost of operating a given grinding machine is of vital importance. In this respect adjustable hoods have the better of the argument, for as the wheel wears, protection flanges must be changed frequently. Such change involves the removal and remounting of the two flanges and wheel; whereas in the case of the hood, the change would involve merely set screw adjustment.

To provide adequate protection for large wheels, the thickness of flanges should be increased beyond those of any flange now on the market. This would mean added momentum to the revolving spindle, which, in turn, would require greater rigidity and strength than is to be found in a large majority of the present day grinding machines.

Since the face of a tapered wheel becomes wider as the diameter decreases, serious inconvenience is caused in all operations where the grinding wheel must work in a slot: as an example, the grinding of automobile crankshafts. Tapered wheels do not permit the grinding of right angle shoulders as do straight wheels.

Laws in most every country and state require the removal of dust from dry grinding. This requires the use of a hood, and if a hood must be used, it might just as well be strong enough to offer protection in case of accident. A proper hood offers complete protection. Protection flanges cannot offer this complete protection, but in instances where a hood would interfere with the proper use of the wheel, a tapered wheel mounted between flanges of a corresponding taper, affords the next best method of protection.

Experts inform us that approximately three-quarters of the present day industrial accidents can be eliminated by properly educating the employee to an appreciation of the hazards to which he is daily subjected. The other 25 per cent of the present day accidents can be eliminated by the use of safeguards. You see, therefore, that in order to keep down insurance rates and claims made under present day workmen's compensation acts; it is necessary to have a clear understanding of the hazards incident to the use of grinding wheels and grinding machinery, and I hope the information given may prove of value in your campaign for safety.

Discussion of Safety in Connection with Grinding Wheels

MR. S. D. SLEETH:—What is the idea of making one side of the wheel flat, instead of both sides being tapered? I believe, some manufacturers claim, they can make a better shaped wheel by having one side flat, laid down on a flat plate, and the other side tapered. We have been using wheels of this sort for 20 years, and we have never had but one accident. In this case the pieces did not leave the flanges.

MR. R. G. WILLIAMS:—I don't know any reason for the statement having been made that it would be better only to taper a wheel on one side than on both, because in manufacturing wheels that are tapered on both sides, in one stage of the operation they are made with only the taper on one side and then the taper on the other side is finally put on. If you must taper wheels at all, it is as satisfactory to do it on both sides as on one, and to obtain the proper degree of safety, with the taper on one side only, you must have double the taper on the one side. If you had a wheel tapered ¾-inch to the foot on both sides, in order to have the same amount of safety, *i. e.*, the same difference between the thickness of the wheel at the hub and where the flanges bear, you would have to have a taper of 1½ inches to the foot on only one side. This was brought out only recently, but is nevertheless a fact, and some of the states are redrafting specifications which will require that if all the taper is on one side, it must be double that on both sides. From a manufacturing point of view, it is as easy to make a wheel tapered on both sides as on one side. The manufacturing cost of a wheel is dependent on the thickness at the hub, but unfortunately the selling price is based on the thickness at the rim, so that a wheel tapered ¾-inch per foot on one side only, taking into consideration the cost and selling price, is a better manufacturing

proposition, than a wheel tapered ¾-inch on both sides. Until recently the idea prevailed that ¾-inch per foot taper on one side was satisfactory; that it was only the taper per foot which was the controlling factor. However, recent investigations have brought out the fact that it is the difference in the thickness at the hub over the thickness of the wheel where your flanges bear, that determines the safety value, or in other words, how much the flanges must spread to let out the pieces of wheel.

MR. S. D. SLEETH:—We have been using our wheels for about 20 years and never had an accident. There was only one wheel broken; it separated into three pieces and they didn't get out of the discs at all. One side of our wheels is flat. We use a large, 20-inch disc for the large wheels, and as the wheels wear down to the limit we take them off and replace them with smaller discs. I thought it is easier to make the one side flat and the other convex, but I am not positive on this point.

MR. R. G. WILLIAMS:—O yes, there isn't question but what the tapered wheel method of providing safety will be satisfactory in the majority of instances, but it is not as good as the hood, because in numerous cases pieces of the wheel have been knocked off outside the flanges, and that is where the danger lies. If the wheel breaks in three or four equal pieces and all are covered by the flanges, the chances are, the pieces will all be held, but it is the pieces that project beyond the area of the flanges from which you cannot offer any protection to the operator, and for that reason, if the size and shape of the casting will permit you to use a hood, it is a better safety proposition.

MR. S. D. SLEETH:—I don't question that; I admit that the hood should go along with it.

"Safety First"—Driving Back The Saloon

By Thomas D. West, Cleveland.

The paper on "Safety First" work which the writer presented at the last convention resulted in his being appointed chairman of a committee to devise ways and means for pushing back the saloon from the doors of our foundries. This involved a task the magnitude of which was little appreciated at the outset. However, it is now conceded that your chairman's efforts gradually developed an issue that has commanded the support of several powerful agencies in our country, a support that is bound in time to obtain excellent results in this special field of "Safety First" work.

The first results came through having quite a number of saloons near foundries and other industries closed by the liquor license commissioners of Cuyahoga County; following this came the adoption of resolutions by the Cleveland, Philadelphia and New England foundrymen's associations asking their respective state legislatures to enact laws which would prevent saloons operating within 500 to 800 feet of the property lines of foundries, mills and other industries. All this is in harmony with the spirit of the following petition which had the full backing of the Anti-Saloon League, the federated churches and temperance organizations of the state of Ohio.

Petition to His Honor the Governor, and the Members of the General Assembly of the State of Ohio.

Gentlemen:

By numerous tests, careful investigations, and by experience it is known conclusively that the use of intoxicating drinks by men in positions of danger and responsibility makes them more liable to accident and less trustworthy, interfering with the general welfare of the men employed in the shops and factories of our state.

We, therefore, petition Your Honor the Governor and the General Assembly of Ohio to enact a law prohibiting saloons within 500 to

1000 feet of the property lines of shops, foundries, mills and factories having more than twenty operatives, the distance to be graduated according as the business may be classified as hazardous by the state or by insurance agencies.

The foregoing petition would have had thousands of signers before September, 1914, had it not been for the fact that the liquor interests have been influential enough to compel a vote this fall on whether saloons shall be free from all restrictions or closed up entirely all over the state, 18 months after election day. This means that there may be no need of petitions and hence all interest and activity in their circulation suddenly ceased in the state of Ohio for the time being.

FIG. 1—LEAVING THE SALOON WITH A BUCKET OF BEER

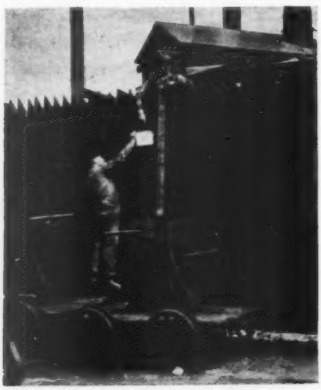

FIG. 2—PASSING THE BEER OVER THE FENCE INTO THE WORKS

While East, last July, your chairman succeeded in obtaining about a dozen strong influential men to become interested in pushing back saloons and replacing the use of intoxicants by workmen with milk. The details of this movement will be discussed later in this report.

This whole propaganda has been a step by step progress, without knowledge of what might be the next achievement. One important step resulted from my seeing a temperance exhibit under the auspices of the Scientific Temperance Federation of Boston, Mass., and Columbus, O: Mrs. Lillian

Burt was demonstrator for the latter, and Miss Edith M. Wills, for the former. My observation of this most excellent means of educating men away from intoxicating drinks caused me to conceive the idea of providing a similar exhibit showing the evils of saloons close to foundries and other industries. Action followed the thought and I proceeded to take pictures of workmen stealing out to get drinks during working hours. After several days trial I found that the number of sentinels generally on the lookout helping the smugglers was such that I would probably get more bricks than pictures, and hence, I abandoned this method of procedure.

FIG. 3—LOOKOUT AT THE SALOON DOOR KEEPING WATCH WHILE WORKMAN SNEAKS THROUGH THE FENCE ON HIS WAY TO THE SALOON

Many Deceptions Practiced

Before proceeding further I wish to state that my experience in back yards and tie-tramping brought me in contact with tricks that are resorted to by employes to steal out to get drinks that would be an eye-opener for many employers if they would attempt what I did in trying to get pictures. Among other surprising conditions I found men who as trusted yard foremen and watchmen served also as confederates to the smugglers. It all forcibly demonstrated

to me that the only safeguard proprietors have against men sneaking grog into their plants is to have the saloons far enough away from their property lines, so that if workmen steal out there will be some chance for faithful supervisors to detect their absence from duty.

Abandoning the enterprise of a traveling photographer, I decided to take posed pictures which would illustrate a few of the many ways and means employed by workmen to carry intoxicants into the plant during working hours without any of the supervisory force being cognizant of such actions.

FIG. 4—WORKMAN RETURNING WITH A BUCKET OF BEER

How the Open Gate Increases Drinking by Workmen

There are firms that have ceased trying to prevent men stealing out to get drinks and permit their passing out through regular gate entrances at any hour. There are in this instance men to be seen going in and out not only with one pail, but carrying two under the eyes of their firm's head officials. If one half of all our firms would follow such practices we would soon be driven back to the day when all artisans or professional men were conceded to have no ability to do masterly work unless they were half drunk. This surely could not be tolerated universally now that all employers are held liable

by the courts for all accidents, whereas a few years back employes were held responsible for what injury they might cause co-workers. We fail to perceive why a free gate is to be recommended for adoption by any firm.

Shrewdness and Ingenuity Displayed in Sneaking Grog Into Workshops

The first of the posed pictures, Fig. 1, shows an employe who has left a saloon's side door and is about to cross the railroad tracks to reach the point where he is seen in Fig. 2 handing the drink to a confederate inside of the fence which

FIG. 5—DRINKING FROM THE BUCKET HIDDEN IN THE FOUNDRY YARD

is about nine feet high. It makes little difference how high the fence is. The grog will get over it even though it might require a block and tackle to do the job.

In Fig. 3 a workman is seen with his bucket stealing out of a hole made by a removable board in the fence. He might

get to the fence by going through a basement or otherwise. Fig. 4 shows the miscreant, with his pail and perhaps a cistern stomach full, returning to steal back into the shop. This special saloon building is about as close to the firm's property line as the fire limit laws will permit. A confederate is seen standing on the saloon steps. There is generally some one anxious to advise the smuggler whether the coast is clear for the sake of the drink he may get to recompense his services.

When the intoxicant is once inside the fence it must, as a rule, be hidden so that none of the faithful supervisory force can have any knowledge of its having been sneaked into the plant. It is often surprising the shrewdness and ingenuity that men thought to have little brains will display in devising ways and means to get intoxicants into a plant and

FIG. 6—AN ACCIDENT RESULTING FROM INTOXICATION

hide them. Fig. 5 shows one of the ways. The barrel seen is in a corner of a foundry yard where the drinker is fairly sure of not being caught in emptying his pail as best suits his convenience. He can get to this in a few minutes so that his absence from duty is not noticed.

It is generally impracticable for faithful superintendents and foremen to be sure that workmen are befogging their brains with smuggled drink until there is a quarrel or some

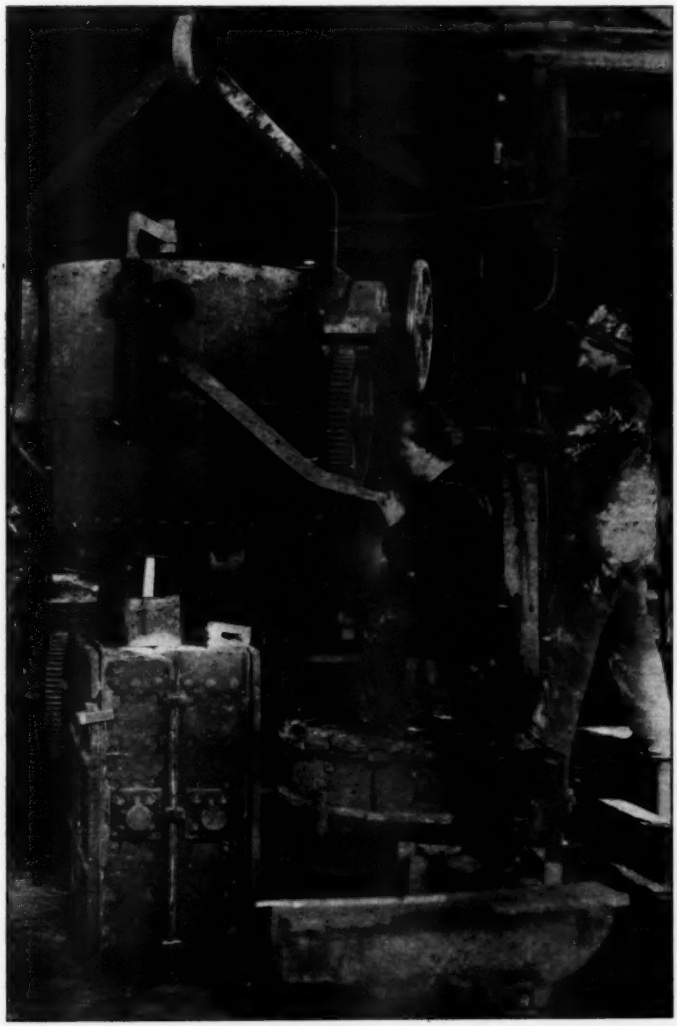

FIG. 7—THE MAN AT THE LADLE CAUSED A SEVERE ACCIDENT BY DRINKING DURING WORKING HOURS

accident occurs. When a supreme court in a state like Massachusetts hands down a recent decision such as the following, we are brought, as employers face to face with an injustice for which it is difficult to find a parallel in any other situation in life:

"A drunken employe is a human parallel to the fragment of physical equipment which may be classified as defective material and cause injury to workmen. If one workman is injured through a drunken workmen the employer's responsibility does not lessen

FIG. 8—MEN BEING PAID IN CASH

FIG. 9 — MAN BEING DISCHARGED FOR INTOXICATION

because of the intoxication. The employer whose defective equipment is the cause of the injury is responsible. The employer whose workmen cause injury to fellow workmen is also responsible."

Actual Occurrence of Accidents by Drinking During Working Hours

Fig. 6 is a posed picture of an actual occurrence wherein a man who went out every lunch hour for a drink brought back beer with him in his dinner bucket, and one day about half a hour after starting the afternoon's work was thrown ten feet and knocked unconscious by the bursting of an emery wheel, that was thoroughly safe-guarded. At the time of the accident this man was grinding small, wedge-shaped steel castings and

not having his wits about him he permitted the sharp end of one to be drawn in between the wheel and the rest thus causing the wheel to fly into four pieces, one of which struck him in the head. He was carried to the hospital where for many hours the doctors could not express an opinion whether he would live or not. In about six-weeks he returned to his work. Another accident, following only a short time after the foregoing in the same plant was due to a man so befogging his brain with drink, unknown to the foreman that he was unable to carefully steady one end of the bottom-pour ladle, illustrated in Fig. 7. It was a hot day and one of the men instead of drinking good water or milk to quench his thirst, stole out between "blows of

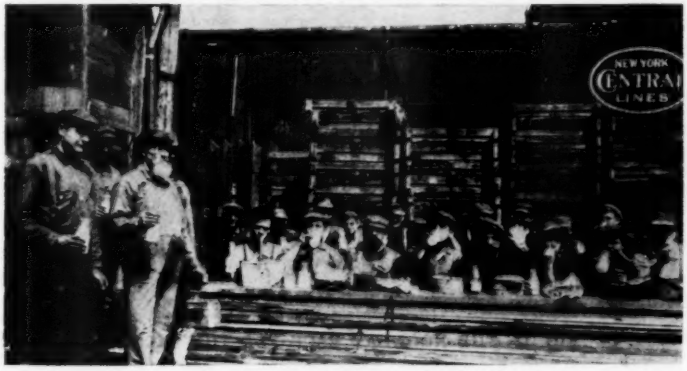

FIG. 10—MILK FOR LUNCH INSTEAD OF BEER

the steel" to get a drink at a nearby saloon. Upon returning and taking one of the handles he could not hold his end of the ladle steady so that the stream from the bottom could pass directly into the gate and fill the mold. Instead it hit the top of the flask and spattered the metal in all directions. This caused every one to run away from the ladle, but not before one man was very badly burned and several others so scorched as to compel their being taken care of by a doctor.

It is true, as some contend, that men can drink during the night or on their way to work in the morning so as to be unfit to be trusted in their positions and on this ground some

maintain that the only way for employers to guard against intoxicants causing accidents is for a community to be strictly dry. While this has much truth, still some have to acknowledge that if we cannot have a whole loaf, a half is better than none. In this connection, men who are addicted to taking drinks during the night, or on their way to work are generally known and "spotted" so that superintendents and foremen can be on their guard, whereas with the men who steal out during working hours, there is no method of warning the supervisors.

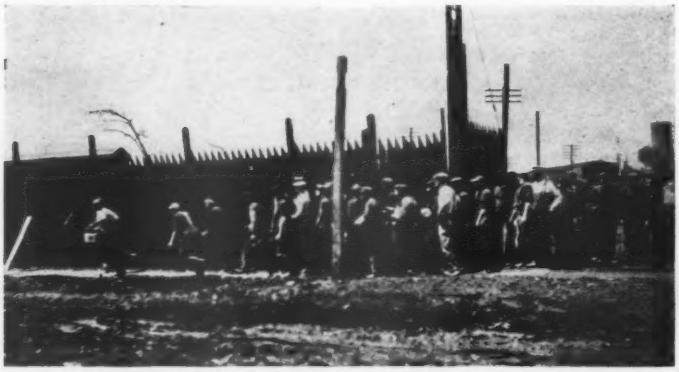

FIG. 11—THE NOONDAY RACE FOR THE SALOON

"Safety First" is Assisted Through Paying Employes off With Cash Instead of Checks

Fig. 8 shows men receiving cash for their wages, a practice generally followed by employers. However there are firms that pay their employes by checks. This involves an evil that exceeds most all others in attracting workmen to saloons. It causes many to commence imbibing intoxicants who otherwise might never indulge. There are no doors that open with a greater welcome and there are no places so glad to cash checks for employes as saloons. It is no unusual occurrence for the bill for drinks to absorb nearly, if not all, of a workman's check, thereby leaving his family

penniless and his honest debts unpaid. A firm that continues this practice when it has made no provision for cashing its employes' checks is not only disregardful of much that is involved in "Safety First" but of morality as well.

A Few Authoritative Accounts of the Percentage of Accidents Due to Drink in the United States

Chas. L. Huston, vice president of a big steel and iron plant located at Coatesville, Pa., states that, "The decrease in accidents in our steel mills for the past six months with Coatesville dry is 54 per cent. The decrease in the application for aid during the same period is 75 per cent. While it was predicted we would experience difficulty in securing labor in a dry town we have had an abundance of labor at all times. Many have sought work in our mills because they wanted to work in a dry town where they could save some of their money."

Mr. Ridgway, of Craig, Ridgway & Son, declared before the members of the Philadelphia Foundrymen's Association last March that liquor is responsible for the majority of accidents in mills and factories. He further stated that "The liquor question has ceased to be a mere moral one and it is now a business question for business men to solve."

Wallace H. Rowe, president of the Pittsburg Steel Co., in a letter to the liquor license judges of Westmoreland county, Pa., says "This company employs 5250 men in its mills, with a payroll of $300,000 per month. We have experienced a growing inefficiency in the service of these men and increased carelessness in the mills, resulting in accidents and death largely attributed to the heavy use of beer, whiskey and other alcoholic drinks. One of the largest steel companies in this district, after an exhaustive examination of the causes of accidents in the mills, makes the broad statement that 85 per cent of such accidents are due directly or indirectly to liquor."

A leading insurance company says: "A man whose nerves have been made unsteady by a recent debauch or

the use of alcohol should not be permitted to operate dangerous machinery or carry on dangerous work. He endangers not only his own life, but that of others." There are few if any who would undertake to dispute this statement, but the great difficulty of the employer who has saloons close to his plant is to discover, before it is too late, when a workman should not be permitted to remain at his job. It is not at all uncommon to see men with befogged brains being discharged as shown in Fig. 9, but the difficulty, as previously stated, is to make this discovery before it is too late to prevent the injury that sneaking to nearby saloons to obtain drink during working hours can do.

Germany's Experience With Intoxicants Causing Unsteady Nerves and Accidents

The Zurich Building Trade's Sick Club learned by statistics obtained during the years 1900-1906 that there were three accidents on Monday to two on other days.

The German Emperor states that, "Nerves are undermined and endangered from youth up by the use of alcohol and that in war, the time for steady nerves and a cool head, victory lies with the nation that uses the smallest amount of intoxicants." The above is given regarding Germany to show that the claims made by many that imbibing intoxicants in that country does no injury are without foundation.

There is much more that might be stated about intoxicating drinks causing accidents in foundries, mills and other plants in our own and other countries if we had sufficient space at our disposal.

Your chairman, since his appointment on this phase of "Safety First" work has written several articles on the evil of saloons being close to foundries and other concerns, prominent among which is one that appeared in *The Survey,* Dec. 20, 1913, which was reprinted by several other influential papers. It is also gratifying to know in this connection that both *The Iron Age* and *The Iron Trade Review* from time to time during the past year have published editorials and articles greatly

assisting this cause and the writer desires to hereby tender them his sincere thanks for their very beneficial co-operation.

Milk Instead of Intoxicants

There is little question but that the existence of saloons close to industries has a greater influence in tempting the young and increasing the appetites of adults for intoxicants than almost any other agency that might be mentioned. Remove the saloon from the proximity of industrial establishments and it greatly helps to educate men away from the drink habit. This calls to mind recent utterances by William H. Barr, president of the National Founders' Association and general manager of the Lumen Bearing Co., Buffalo, at a banquet given in his honor by the Cleveland Foundrymen's Association last January. During the discussion of safety work at this banquet Mr. Barr stated that for a while he did not know whether he was operating a foundry or a brewery. He said that conditions became so serious that he concluded some efforts must be made to cause less drinking of intoxicants by his employes. He conceived the idea of trying to induce his men to drink milk in place of beer, especially during the noon hour. He installed a refrigerator in his plant and asked one of his trusted employes to commence this practice. For a while this workman was scoffed at by his fellows but Mr. Barr said that an inspection of the refrigerator about a couple of months later disclosed the encouraging fact that 47 bottles of milk had been placed there for that number of workmen who had voluntarily adopted the milk-drinking habit. The facts regarding this innovation have been published before but are repeated here to help complete this paper.

How to Increase Milk Drinking by Workmen

A realization of the great importance of Mr. Barr's innovation in helping men to discard drinking intoxicants caused me to labor for its extension. To this end I interviewed one of the largest milk dealers in Cleveland to solicit his interest in

doing all he could to replace beer with milk in the city's industries. I was greatly pleased to be informed he had done some missionary work in this line and was satisfied that if some educational or welfare society would take an interest in the problem great progress could be made and accidents in our plants could be materially reduced. Believing this cause could be greatly aided in our city by appealing to proprietors I sent out a large number of letters, which read as follows:

Cleveland, Ohio, June 19, 1914.

Dear Sir:—Many are now taking a keen interest in the work of pushing back the saloon, but in doing this, it is generally considered something should be had for the lunch hour to replace the beer and hot soup furnished by the saloon.

In an interview the writer had with the Belle Vernon Mapes Dairy Co. of this city he learned that the following firms and others recently started to replace the drink that befogs the brain with good milk that allows man to retain his wits and efficiency.

The White Co., 300 pint bottles of milk daily. Chicago Pneumatic Tool Co., 100 pint bottles of milk daily. Stearns Auto Co., 100 pints.

Willard Storage Battery Co., 80 pints. Warner & Swasey Co., 30 pints.

National Lamp Co. at all plants. Ivanhoe Metal Works and others.

The milk is delivered to the above firms who have the bottles packed in ice at least at a cost no greater than that for which it can be purchased otherwise by the men.

I enclose a leaflet which shows how one workman encouraged 46 of his fellows to replace beer with milk. Perhaps you might get not only one, but several of your employes to try this innovation.

Hot weather is a good time to start this practice and you might surprise yourself with the results obtained.

To aid "Safety First" work and efficiency in your employes we would be pleased to have you give this matter your consideration and if you would favor an interview with a milk merchant on the subject we enclose a stamped envelope which you can forward with your request. Trusting you may feel favorable toward encouraging the subject of this letter, I am

Yours very truly,
Thomas D. West.

Oscar Bestgen, expert for the dairy company mentioned above, stated he expected much good to come from my letter and that he was making searches to devise improved methods to decrease the cost of keeping the milk cool for the men. While in the east I stirred up considerable interest in this movement and it is believed that with individual and collective effort in a few years this practice will become universal in the foundries, mills and factories of our country.

My youngest son, Ralph H. West, president The West Steel Casting Co., Cleveland, recently has installed a refrigerator to store milk for his men. Fig. 10, shows many of them taking their lunch out of doors in the shade instead of following the old practice of nearly exhausting their strength in a mad race for the saloon when the lunch hour whistle blows. The latter practice is shown in Fig. 11. Our firm supplies the ice to keep the milk cool. A pint bottle costs the men 4 cents. They purchase checks in quantities and hand them to a care taker when they wish. The refrigerator is without a lock and the men are put on their honor to not take a bottle without depositing a check with the clerk who is in another room. Some of the men not only have a bottle for their lunch hour, but also order one for the mid-morning or, more frequently for the afternoon during the heat of casting time. In other words they are free to obtain it when they please and to order as much of it as they desire. They are finding it supplies a strength to the body that is invigorating and lasting.

Choose Between The Drink or the Job

Agitation of back with the saloon as a "Safety First" measure has done much during the past year to influence the strict disciplining of men addicted to drinking. Most everyone recalls our navy's late restriction on the liquor question. However, of the many prohibitive steps employers are now taking to cut out the drink, we give only the following to show the tendency of the time. A recent editorial in the *Chicago Inter-Ocean* says:

> This is the day of the sober man. Time was, and not very long ago when the brilliant alcoholic could hold a job in almost any trade or profession. That time is past. Industry has come to realize that dependability is better than brilliancy and that brilliancy itself is more common with men of clear heads than with those whose brains are muddled with alcohol.

The Atlanta Constitution says:

> You young men or middle-aged men or old men had best take note of the sign of the times and make up your mind to the fact that in this day and generation it is your drink or your job. You may compromise with your conscience or laugh at the temperance orator but

you cannot fool the man with your job in his hands. Nor can you sign a truce with the growing octracism that separates success from the man who habitually crooks an elbow.

There is little doubt but that several states before November will witness an agitation of questions involved in the use of intoxicants, especially in the cities, such as they have never seen before. It behooves all desirous of advancing "Safety First" work to help shape events so that in any of the entanglements of politics to come, the saloon shall at least be forced back 500 to 800 feet from the property lines of foundries, mills, factories and other industrial plants in order to assist the work of reducing accidents.

Shall a Manufacturer Figure Costs Before Fixing His Selling Price?

By F. J. Stephenson

For the past year it has been my privilege to represent the National Association of Stove Manufacturers in its efforts to secure the general adoption of uniform methods for calculating costs of stoves; and your secretary has asked me to tell you something of my experiences.

What is said will be the result of opinions formed, not from a theoretical study of the subject, but from actual daily efforts to apply the principles of a uniform cost system.

After a year of actual experience I do not hesitate to say that we are meeting with a greater measure of success than I had dared hope for. Uniform cost methods are no longer a theory with us. They are an accomplished fact. Before the close of this fiscal year it is fair to predict that factories producing 85 per cent of the total output of coal and wood stoves manufactured in the United States will be computing costs by uniform methods.

Do not be confused by this statement. I do not mean that these stoves will all cost the same, nor do I wish to give the impression that the factories all use identical methods. Costs will always vary with economic conditions and efficiency will always assert itself and permit production at reduced costs. Then again it is necessary, because of peculiar conditions in various plants, to alter their methods to correspond to their individual peculiarities.

Instead of using the words "uniform methods" we use the words "uniform theories", and today the large majority of the stove plants have adopted uniform theories, and what is more, they believe in these theories, and the results obtained.

Let me ask you to look upon costs as having two separate and distinct qualities or functions. First, the commercial cost which represents the cost of production and selling. Second, control costs, or the costs which we derive from day to day, week to week or month to month, to enable us to control our establishments and operate with greater economy.

For the purpose of this talk we will consider the former almost exclusively. As competitors in one line of business you are not so much interested in the economical management of the other fellow's factory as you are in providing him with a safety device which will prevent him selling a dollar's worth of goods for 90 cents and thus upsetting the market.

I called on a manufacturer of stoves and after the usual conversation he asked me to figure the cost of a certain stove. I did so, after assuming overhead factors based on my knowledge of other concerns similar to his. My cost was about $3.50. He figured his way and the cost was $2.40. I asked him which was right. He said he didn't know. The point I made was that he didn't know and couldn't know under his methods. We continued our talk and he was obsessed with the fear that if he put in our cost system his goods would cost more by reason of it. I answered him, "How can they cost more? You do not add any clerical work nor expense. You pay out the same money you do now, and you get the same returns. The only difference is, you embrace all your expenditures in your costs, and though you probably will figure your costs higher than you do now, you will know that you are only telling yourself the truth. Surely you are not afraid of the truth." Today this man is using our cost system and you would have a hard time shaking his faith in it.

Another amusing case was that of a manufacturer who admitted that he figured his costs too low. I asked why he did it and he replied that if he added a higher overhead he couldn't sell his goods. "Why," I replied, "you could sell them just as well as you can now. What would be the difference?" "Yes," he said, "but we couldn't sell them at a profit."

I gave up this case in despair, but I did give him this story to think over. "One of your traveling men had to catch a train. It was ten blocks to the station. His watch showed

him that he had five minutes to catch it. He couldn't run the ten blocks in five minutes. A clever idea comes to him. He turns his watch back ten minutes, thus allowing himself fifteen minutes to leisurely walk to the station. Did he catch the train?"

If we could only realize what a cold-blooded business proposition costs are. If you pay five dollars for a pair of shoes, you pay five dollars. There is no way out of it. What you can sell it for has nothing to do with its cost. Perhaps you can sell it at a profit and perhaps you cannot.

I met a manufacturer who admitted that he figured certain lines of his goods too low, and said he didn't care to know what they cost him. He had to make them and had to sell them at a certain figure. It was necessary in order to hold his trade.

We all know these conditions exist, but it does seem like either cowardice or poor business, or both, to not be willing to face the music and know what this policy is costing. Perhaps this loss is an advertising or selling expense. One would not be willing to incur an expense from any other source and not know what it costs.

Another fallacy, and probably the most difficult one we have to meet, is that insatiable desire to increase volume by cutting the price. You figure that you can do a hundred thousand dollars' worth of business at a fair profit; now, if you can add twenty-five thousand more at a price representing your costs less your fixed expenses, you will profit by reason of reduced cost of production of the whole. Beautiful theory. It is like figuring profits on a chicken farm. But a more fatal boomerang was never thrown. If you were the only clever fellow figuring this way, you might get away with it for awhile, but eventually even you would eat into your standard production. But when you consider the other manufacturers and know that they can figure the same way and estimate the inevitable results the destruction to business becomes apparent.

It is hard to conceive how a manufacturer can favor one line at the expense of another. Remember you are figuring

costs and you want the truth. Didn't all your goods actually cost you the same proportion of overhead?

Always look at a question of this kind from two angles, equity and expediency. Is it equitable to relieve one portion of your product from its just burden of overhead? Then is it expedient to do so? Always bearing in mind that the rule you apply to yourself may be applied by your competitor.

When all is said and done, a cost system is conducted chiefly for the purpose of determining commercial costs. And costs are determined to ascertain at what price we can sell our goods, to mark the danger line below which we cannot sell.

We are told that in one of our Civil War prisons, the prisoners were shot if they approached the walls. As a result, the prisoners themselves drove stakes in the ground and tied strings to them, thus establishing a dead line, as they called it, beyond which they may not pass. Gentlemen, your cost figures represent your dead line. You will cross it at your peril. You may go as far as you like on the other side, so long as you do not use a balloon, but you cannot cross the dead line without incurring the penalty.*

Some years ago, before the advent of the Sherman law, efforts were made to correct the practice of selling a certain article at prices below cost. Everybody was doing it. A dozen manufacturers met around a quiet table and discussed the cost of the article. Taking it piece by piece, all agreed that it could not be made for less than $3.75. In less than a week it was being sold for $3.25. I maintain that some of these men were not convinced. Some fellow reasoned that if that article cost so-and-so $3.75, he knew that he could make it for less, because he had a small plant and paid low salaries, and if it cost so-and-so $3.75, he concluded that he could make it and sell it for $3.25. Our association has taken the ground that the only remedy for this condition is to see that each man figures his cost for himself. We are convinced that he will believe *his own* figures when he will believe nothing else.

The word "costs" has been variously defined and I venture to suggest the following: The cost of articles manufactured and sold is the difference between the selling price and the profits. The practice of figuring costs and then allowing for

expense is to be condemned. Note the relation between the words expense and expenditure. Material is an expense, so is labor of production and labor of selling. They differ only in that the relation of the former to the article manufactured is the more readily identified.

For a number of years arguments have arisen between accountants over the academic question of whether administration and selling costs should be figured on the first cost or selling price. Not attempting to determine the question in its application to business in general, but having in view the casting jobber, there appears to be but one answer. He has no regular selling price for his product, no list price such as the merchant maintains. There remains no alternative. He must include administrative and selling expenses as a part of his costs based on prior cost, or first costs as some call them.

The National Association of Stove Manufacturers has settled this question satisfactorily, and the results so far accomplished have justified their methods.

We have not attempted any ultra refinement in our methods. We admit that in the foundry the overhead costs are distributable partly on the pound basis and partly on the molding cost. In machining and assembling departments we distribute the overhead of each department on the direct labor of that department. All charges for depreciation, power, light and repairs are sub-divided and charged to the various departments and become a part of the departmental costs.

After we have determined our departmental costs, then we add to them the value of material and distribute our General Manufacturing, General Distributing, Salesmen and Discount Costs on the total.

A short history of our efforts will perhaps interest you. The present uniform system was adopted in 1907 and a manual of costs prepared giving minute instructions for keeping the several accounts and working out the costs. The secretary spent such time as he could advising members and the system was explained at the various association gatherings.

In 1913, six years later, it was decided to employ a man to spend all his time among the manufacturers advocating, explaining and introducing this system. I was employed and

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began work in September of 1913 and have visited nearly all the factories.

It is a surprising fact that after all the explanations and work that had been done, very few were using the system with intelligence. I think it is conservative to state that not over 50 per cent of the manufacturers who had adopted the system had grasped its full significance, and yet the system is simple. Little difficulty was encountered in putting them right, but it required the personal touch to do it. It was necessary to take their own book accounts and manipulate them to arrive at the expense factors, but when once done, the entire problem was cleared. In numerous instances they gave me their ledgers and assisted in the arrangements of the accounts, and in every instance they were convinced of the accuracy of the results and were content to abide by them.

It is not so easy, however, to convert a man who has never used the system. He points out the fact that he has made money under his old methods, which is proof sufficient that he has been on the right track. During my first eight months only 25 men decided to alter their methods to conform to the uniform system. While these figures were not discouraging, they testified to the reluctance of manufacturers to make a change. He claims that he has a cost system as good as ours, and perhaps points out the weakness of our methods.

We are free to confess our weaknesses, but maintain that no system of costs is free from them, and right here is where the value of association work asserts itself.

I have read with much interest several articles heretofore presented to your association. One point, however, has not been brought out so prominently as I would wish, and it is this one point which I wish to emphasize and invite particular attention to.

There are two decided advantages to a uniform system of costs, the first one has been well emphasized in the past. It will dissipate ignorance. But there is another equally vital point. It is not only the man who is ignorant of his costs who causes trouble, but is also the man who figures differently from you. In an argument he could probably find just as

good authority to support his theories as you could yours. He merely has different theories.

There is no correct method of figuring costs. We all make mistakes. Our overhead charges represent half or more of our total costs and these charges are of a necessity distributed on a theory. You cannot prove how much superintendence, or how much taxes entered into the cost of this table or that chair. You use a theory to determine it. Now, just so long as you have different theories you will produce different results. You meet and debate these theories, and continue to hold to different opinions. They are merely *opinions*. You don't *know*. You cannot *know*. If the truth were apparent, there would be no ground for argument, and the mere fact that you can argue is proof that one theory must be about as good as the other. Now, how much better it would be if you all accepted the same theory. Here is an illustration I often make. Assume that you and I each run a factory, both are equally efficient, both make the same line of goods. You make a stove and figure its cost at nine dollars, and a range at fifteen dollars. I make the same stove and figure its cost at ten dollars and the same range which I figure at fourteen dollars. You offer your stove for sale based on your nine-dollar cost. I have to meet it with my ten-dollar article. I offer the range for sale based on my fourteen-dollar cost and you meet it with your fifteen-dollar range. Each accuses the other of being a price-cutter. How much better off both would be if we figured the same way. It does not matter which way, so long as we are nearly right. The essential thing is that we agree on our theories.

A uniform cost system not only dissipates ignorance of costs, but eliminates that competition due to difference in theories, which is not ignorance, but differences of opinions solely.

There is no supreme authority on costs save as we create it. In this respect our cost problem is not dissimilar to our municipal problems. There is no supreme authority on conduct save as we create it. We call this supreme authority the law. In a theoretical analysis a law may be proven to be incorrect, just as we can find flaws in a cost system; but we stand behind

our laws and say they are right because they are the constituted authority. Just so will our cost system be right when we stand behind it and say it is our constituted authority. And just as our laws work out to the ultimate good of all concerned, so will our constituted system of costs. That is, insofar as our relation to each other and to the trade is concerned, no injustice will result, for we will all be affected the same.

You meet here as legislators to establish laws to govern your actions. Among the questions you have to consider is that of computing costs. You are exactly in the position of legislators deciding a question for your constituency. You cannot formulate a law which completely covers every phase of life. Sometimes it works a hardship. Yet you would not consider a municipality without governing laws. No more should we consider the operation of our business establishments without governing laws. We recognize that in the solution of our municipal affairs a reasonably good law is infinitely better than no law at all, and it is just so with our factories, a reasonably good set of established formulas equally applicable to all is infinitely better than to have each man working out his own destiny after his own fashion, and it would be a poor law indeed if every man heeded it, and was governed by it only when he saw fit, and it is a poor cost system indeed that a man heeds only when he feels inclined to do so. We do not cease to be competitors because we subscribe to uniform formulas any more than when we consent to the payment of taxes or any other burden or restriction placed by law. If all are affected equally, these requirements cease to be a burden and beyond compliance with the law's requirements we continue to compete.

As an association, you have adopted and recommended a certain cost formula. It is perhaps regrettable that you cannot enforce its adoption, but it does appear altogether desirable that you should expend every energy to urge its adoption. Perhaps your formula is not suitable to all. Perhaps it is not perfect. Very likely such is the case. It is the history of evolution that nothing remains unchanged. As a result of the study of conditions by the cost expert of our association, considerable changes were suggested and adopted at our last

convention, and it is only a recognition of the incontrovertible laws of human events to predict further changes.

One case which came to my attention merits mention. The factory had an excellent cost system, just as good theoretically as the one I was teaching. I freely admitted the fact, but suggested the advisability of all working together and pointed out the possible advantages that could accrue to the manufacturers through a man spending his entire time studying various factories, their methods and formulas, and the development that would naturally ensue. This man became a staunch advocate of the scheme, and is a supporter of the policy of developing an efficiency bureau within the association for the benefit of its members. Up to the present time this idea has developed so far as to instruct the cost expert to tender his assistance to all members in the solution of any of their office problems. I think I can conservatively state that the savings thus effected are greater than the salary paid irrespective of the question of greater efficiency.

I venture to suggest your consideration of the advisability of such a movement. Assume that you employed a man to give his entire time to the study and solution of the problems of office work, having him work along lines to produce uniform results in figuring costs. A man who visited all your plants, talked heart to heart with your office men and managers, took your ideas and added those of your neighbor to them. What would he not be able to accomplish? Offering a concrete example, I was impressed in one southern factory with a minor record they kept. In a northern factory I saw another related to it. I embodied the two with some ideas of my own and will soon offer the result to the membership. Unless I am mistaken it will prove extremely popular.

Some associations have gone further than we, and maintain efficiency bureaus to work out the shop problems as well. It is all along the same line.

This whole question lies on the foundation of confidence. When our cost expert was employed it was uncertain whether managers would confide in an association man. I have found it to be a rule that few men give their confidence freely upon the occasion of the first call, but it is probably conservative to

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say that of all the factories visited, 90 per cent have now torn down their barriers and discuss their private matters with me as freely as with their doctor. And why not? The situations are not dissimilar. Did it ever occur to you how much the doctor learns from his patients? Yet he does not reveal their confidences. Visiting a factory for the second time this summer, I was told that they would like to discuss the situation, but that there was certain information they would not care to divulge. I stayed a few days with them, and in the end nothing was withheld. The information they had specially guarded was found to have been incorrectly compiled and was misleading.

It has been found in many instances that where manufacturers have attempted to apply the system of uniform formulas to their business they have followed the manual too literally. Uniform methods multiplied by uniform conditions produce uniform results, but in few factories do we find uniform conditions and it is necessary to qualify our methods to meet the unusual conditions. Different factories do not charge the same items into overhead, or what one man charges into one department, his competitor may place in another. There is little doubt but that the best way of settling these differences is to have some one man visit the plants and correct them.

Probably in no two cases have I installed systems identical in all particulars. The end we seek is uniform results, and not the use of identical methods.

I have dwelt at some length in support of a uniform cost system and now approach the central thought which I was asked to talk upon—"Shall a Man Figure Costs Before Fixing His Selling Price?" Whether a man should do this is one question, and whether he will is another. Clearly he will not figure costs, or if he does, will not be guided by them, unless he has confidence in his figures. I have sought to lay stress on the necessity for a system, a law, if you please, as inviolable as the laws of the land. We must believe that our theories are right and that the results are equitable. We cannot believe and follow them today and disregard them tomorrow. It is granted that cases do arise where it seems inequitable to adhere strictly to our system, but these cases are rare and must be

studiously considered. The moment that we exempt one portion of our product from its burden of overhead, we place an excess load on all the remainder of our product.

You have an accepted formula. It is right. It is right because you have accepted it and adopted it. When it ceases to be right you will change your formula and not twist and turn and manipulate the results acquired by the use of your formula.

In a government arsenal a foundry foreman was instructed to follow a certain formula for mixing steel. Called upon later to report, he maintained that he had followed the formula, but had added a few pigs of iron to bring up the amount. Silly, you say, but parallel to the man who figures his costs and adds or deducts from his result to meet conditions.

Another common error is made in loading excess costs on a certain line of goods because they sell at a better profit, on the plea that they can stand it.

There is a certain psychological influence which we must constantly battle. An influence which prompts us to fool ourselves and figure the costs at what we would like to have them and not at what they are. I sometimes think that a man who sells goods should never figure the costs. He is liable to deceive himself.

We are inclined to look upon costs and cost systems as complex. There is nothing further from the truth. All a cost system is calculated to show is the bare naked truth, and in figuring costs as in our every-day affairs we complicate matters when we sidestep the truth. We tell an untruth and lo, another lie is necessary to cover it. The path of simple truth is the only straight line. A cost system should be simple, the shortest possible method of recording events in order that they may be recalled for guidance. It is applied common sense, nothing more. It does not require skilled accountants, just a clerk of ordinary intelligence, who is capable of recording every-day events.

If one seeks ultra refinement and is inclined to magnify errors which we admit, there is no end to the maze he may enter, but this is uncalled for. A simple system, if adopted

by all, so that all are guided by the same principles, will effect results more beneficial than elaborate methods.

Confidence in his own figures is the all essential desideratum. A man must believe that his books are telling the truth. He is more likely to have confidence in a system which he can comprehend even to the extent of criticising its weaknesses than in a system more correct theoretically, but rather beyond his full comprehension.

If you seriously consider making a determined effort to induce all foundries to use uniform methods of figuring costs, I would venture a few suggestions.

First.—Make your formula simple, so that it may be fully comprehended by the least educated man.

Second.—Prepare detailed instructions for keeping the various accounts, stating as nearly as practicable just what shall be included in each. This may not help the manager so much, but it will help the bookkeeper.

Third.—Prepare a few simple forms, especially a form for computing costs.

Remember the vitally essential thing is that the manager should know just *why* he keeps certain accounts, and the bookkeeper should know just *how* to keep them. Both must know that their results are correct.

When our cost system was first introduced it embodied recommendations which were afterwards changed to insure more correct results. But though they have been modified since then, I believe that it was wisest to start just as they did.

You will not find it necessary to worry over an attempt to provide a system so perfect that it will comprehend all cases. You cannot do it if you try. But wouldn't it be infinitely better if you all settled on a few theories and lived up to them, than for each of you to work independently, each working out his own methods and all arriving at different results, biased by your own individual views of a set of theories which you are unable to prove even after your decision?

You will debate the question whether or not it will pay you, as an association, to employ a man to introduce a uniform cost system. Such a venture will cost you from $5,000 to $10,000 a year.

You will doubtless confine his efforts at first to that of cost work, but I have found it necessary at times to offer other suggestions to create interest in costs. In one plant I was met by the statement that in all their matters they had consulted experts. The manager claimed that their cost system and office methods were nearly perfect, etc. I casually admired some of his work displayed in his office. I was then invited to visit the shop. He was putting in a new railroad siding. I suggested an elevated track. The idea appealed to him. I suggested a minor change in his barrel room. When we returned to the office he showed me his books and like the others he fell in line. It is advisable to allow some latitude to a cost man. He will find demands for all his resources.

While you will start your man with the sole idea of harmonizing cost methods, I predict that you will retain him to develop office methods and as an adviser in administrative affairs, and it would not be strange if you developed an efficiency bureau. Surely your interests are common and co-operation is the spirit of the age. The farmer years ago learned the value of spending a half hour leaning over a neighbor's fence discussing pigs and potatoes, and they were not secretive as to methods. Manufacturers have been afraid the other fellow would learn his secrets. The farmers have had few, if any, secrets, yet for all this some have succeeded and others failed, but who will say that nothing was gained by the co-operation that did exist? Today the nation and various states are encouraging instruction in farming, have experts and experimental stations everywhere. Does farming suffer? Are not the farmers richer than ever before? Wherein do manufacturers differ? Your association has done much to develop ideas. Your conventions and the records of your proceedings are of incalculable benefit. You have not been selfish in giving information. The leaven is planted and is at work. A good man starting perhaps as a cost man and developing according to your demands will be an investment worth probably more to the foundry industry than any undertaking which you may consider.

The manufacturer who now has a perfect system may not use him, but will benefit from the work he does for others.

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It will tend to strengthen the entire industry by eliminating not only the competition due to ignorance of costs, but competition due to differences of opinion as to what are the costs.

Business will then go to the man who is able to produce goods cheapest or who is willing to sacrifice more of his profits, and not only the industry will be helped, but the public at large will be less imposed upon by the establishing of better business methods.

"Should a man figure his costs before fixing his selling price?" You surely do not want me to take your time discussing this question. It is not an actual question. No one raises it. The thought is axiomatic, self-evident. You *must* figure the cost before fixing your selling price. Common business prudence demands it. We will drop the thought and raise another.

"How shall we figure the cost before fixing the selling price?" Here is a vital question, and will you agree when I answer it this way? "Establish a method approximately correct, and all abide by it. Create a law of methods which becomes an authority, and obey the constituted authority. When the law becomes inadequate, change it, but always obey the law. No man of himself is always right. The law must govern, the law must be supreme, the law must be right because it is supreme."

Estimating the Selling Price of Castings

By A. O. Backert, Cleveland.

To ascertain the methods pursued by foundrymen in estimating the selling price of castings, an investigation was conducted, 1000 letters having been mailed to all of the members of the American Foundrymen's Association and leading jobbing foundries of the United States. A series of 11 questions was asked and a total of 109 replies was received. It frequently has been stated that the number of foundrymen who make careful estimates on work is not large, yet the bulk of the replies received indicates that an earnest effort is being made to quote intelligently on new work. It cannot be denied that the practice of guessing at the selling price of castings is still too prevalent for comfort and it is hoped that some standard system of estimating will be evolved which can be followed by foundrymen generally. The questions submitted follow:

1.—How do you determine the selling price of your castings?
2.—Do you employ an estimator to compute the selling price?
3.—Do you follow any special rule or formula in preparing an estimate?
4.—What ratio does your overhead expense bear to your labor cost?
5.—What do you include in your overhead expense?
6.—In making an estimate, what allowance do you figure for contingencies such as haulage, special rigging, pattern repairs, rejections, etc.?
7.—What percentage of profit do you estimate on each job?
8.—Does the estimated percentage of profit vary on heavy and light work?
9.—How do you estimate labor cost on a job and what do you include in this estimated cost?
10.—How do you estimate the cost of molten metal in the ladle?
11.—Do you base your estimates on data previously obtained from your cost system?

It was surprising to note that practically one-half of the foundries employed estimators and operate estimating departments, while a number delegate this work to one of the plant executives. Only one empirical formula was reported for estimating the selling price of new work. Many foundrymen

are averse to accepting formulas at their value, believing them to be the obscure symbols of the abstruse sciences. However, in several well-managed shops a similarity of formulas has been found, which would indicate that the adoption of a universal system would not involve many difficulties. This formula used by several foundrymen, follows:

$$W + L + 1\frac{1}{2}\ L + C + P = \text{the selling price.}$$

W represents the weight of the casting and this multiplied by the cost of the metal in the ladle gives the cost of the metal in the casting; L represents all labor, including molding, coremaking, melting, chipping, etc., and 1½ L represents the overhead charges; C represents contingencies and includes casting losses, haulage, special rigging, pattern repairs, etc., and P represents the profit.

The ratio of overhead expenses to direct labor cost was found to vary considerably and as high as 3:1 was reported. Numerous interesting replies also were received in answer to the question regarding percentage of profit estimated and in most cases competition governed this entirely. With few exceptions, all the foundrymen answering the questions submitted reported that they based their estimates on data previously obtained from their cost system. This would indicate that an earnest effort is being made to arrive at accurate costs, but evidently the systems in use are inadequate or they are improperly applied.

In the following an effort has been made to summarize the replies as far as possible, although the wide variance in the nature of the answers made it almost an impossible task to properly classify them:

1.—How do you estimate the selling price of castings?

The purpose of this inquiry was to ascertain what methods are pursued in fixing the selling price of the foundry product. In a measure, the inquiry was somewhat broad, nevertheless the replies received indicate a wide variance of methods and the need for the establishment of some standard system for making

estimates on new work. The following briefly compiles some of the replies:

Nine foundries replied that they make their estimates by the records of the cost of similar work; five determine the selling price by actual cost and add the profit; three estimate the selling price by the cost of molding, iron and overhead, to which the profit is added; one foundry fixes the selling price by estimating the cost of producing on the basis of daily output in pounds per molder; another replied that the price is fixed by the amount of labor expended, materials used, overhead charges, cost of changing flasks and special rigging; one replied "What we can get and by experience"; by figuring each job separately, one reply; three replied "Make close estimate on anticipated cost and add percentage of profit, which varies with the kind of casting;" judgment of estimator and basis of cost records, one; selling price based on American Foundrymen's Association standard cost system, one; by cost and what we can get, four; based on price of pig iron, one; value of molten metal at the spout, plus the direct labor cost and a profit of 8 to 20 per cent, one; estimate molding and core labor, to which is added overhead, cost of molten iron and selling expense, 15; two concerns that do repair work for railroad and mills, respectively, replied that the price is governed solely by local competition and that a uniform price for both light and heavy castings for the entire year is made; by estimating cost and percentage of profit, seven; cost of molding, overhead, 5 per cent for loss and defectives, 25 per cent for loss in blowing and 20 per cent net profit, reply from a side-blow converter plant; by taking average cost of several melts, one; total of all materials, labor, overhead and 25 per cent profit, one; direct labor plus melted metal plus indirect cost plus overhead and profit, two; don't estimate if we can avoid it, take a few castings on trial, figure molding cost and make price for long run, one; price based on cost of molding, one; price based on direct labor, one; by actual cost of each pattern, one.

2.—Do you employ an estimator to compute the selling price?

Many of the most progressive shops employ special estimators who are trained to fix the selling price of castings from blue prints, patterns, etc. This is a specialty that has developed in recent years and it is unfortunate that estimators are not employed more generally. A total of 43 foundries replied that they employ estimators; 39 are without estimators and a special estimating department; seven delegate this work to the cost department and three to the sales department. In addition, a number of foundries replied that the estimates are made by the superintendent or manager with the co-operation of the foundry and pattern shop foreman.

3.—Do you follow any spelial rule or formula in preparing an estimate?

The purpose of this question was to ascertain whether

any empirical formula is employed, which in a simple manner and by symbols would contain all of the charges necessary in estimating a selling price. Fifty-five foundries replied that they follow a special rule, but in most instances no formula is employed. Forty-three replied that no special rule or formula is followed. One formula submitted follows:

$$P = \frac{2.14\ M + W\ (F + 1)}{W}$$

P = cost per pound.
M = the molding cost.
F = the cost of melting.
1 = cost of iron including shrinkage and
W = the weight.

The overhead is included in the molding cost charge which is figured at 214 per cent, making the overhead 114 per cent of the labor cost.

4.—What ratio does your overhead expense bear to your labor cost?

Of all of the questions submitted, none is of greater interest to foundrymen and the wide variance in the ratio indicates the source of low quotations on castings and the reason for the large number of failures recorded annually in the foundry industry. While the ratio was asked for, many of the replies were in per cent. It is surprising that this ratio varied from 1/10:1 to 3:1, although one foundry reported a ratio of 6:1, which evidently is an error. With a normal production a ratio of 1.5:1 is generally accepted as a safe margin for overhead to labor cost, although when production decreases overhead automatically increases. This is a feature overlooked by many foundrymen and in place of increasing their overhead per pound of output when production declines, prices usually are reduced and losses necessarily must be incurred.

The following briefly notes the variety of replies received and the differences in this ratio as reported by various foundrymen:

Two hundred per cent on actual wages paid molders; 100 per cent on wages paid coremakers and where special cleaning is required 100 per cent is added to cleaners' time in the cleaning room; differs materially with class of castings made; ratio of overhead to productive labor cost, 300 per cent; 142 per cent of net productive labor in 1913; add 125 per cent to direct labor and 19½ per cent to total cost for selling; normally 150 to 175 per cent according to business conditions and melt; light castings 50 per cent and heavy castings 34 per cent; foundry 65 per cent and office 25 per cent, making a total of 90 per cent; average 1913, 220 per cent; average for five years 114 per cent; molders' over-

head 150 per cent, which includes cost of cleaning and coremakers and 100 per cent includes cost of material for cores; about 16 per cent, the salaries of the management being included in the labor cost and the salaries of the officials in overhead; 18 to 30 cents per productive hour; overhead varies on each job; varies on different operations as overhead is divided up and included in the burden for each operation; 100 to 150 per cent on molding labor; foundry overhead 45 per cent and general overhead 45 per cent; depends on what percentage of our capacity we are operating, running 40 per cent capacity the overhead is 50 per cent or more of our total labor cost; ratio of overhead to labor cost was 214 per cent during the last three months and this varies every day throughout the year. In addition to the foregoing numerous replies were received with estimates from 10 to 300 per cent. A number of these follow: 10, 20, 33 1/3, 43, 50, 85, 90, 100, 142, 172.4, 220 and 300 per cent.

5.—What do you include in your overhead expenses?

The purpose of this question was to ascertain what fixed charges were included in the overhead and with few exceptions, most of the foundrymen endeavor to include all charges that cannot be classed as labor, material, etc. One foundry replied that all factory expenses, including depreciation and factory supervision other than productive labor and material, were classed as overhead expenses, but minor materials such as core sand, etc., are not passed through the stores, but are charged as an expense and are included in the overhead. A few of the replies received follow:

Melting, fuel, supplies, repairs to equipment, cupola labor, salaries, errors, laboratory expense, but this does not include the interest, depreciation and general superintendence of the plant; executives' salaries, clerk hire, insurance, rent and taxes, traveling expenses, teaming, etc.; interest, depreciation, advertising, rent and repairs to equipment; all expenses except wages of molders and coremakers; all supplies, maintenance expenses, etc., and all labor except direct productive labor, but general office expense, including salaries, insurance, taxes, selling expenses, etc., are figured as a percentage of direct labor cost and are added to this item; insurance, taxes, interest, legal expense, salaries, office expense, general expense, repairs, defective loss, shipping, yard force, superintendent and clerical help, accidents, laboratory, advertising, commission and traveling; everything except raw material and direct labor is charged in the overhead; salaries, expense of building, freight and teaming, office expense, insurance, interest, general expense, expenses of small tools, stable, machinery and fixtures, traveling, advertising, supplies, lighting, royalties, power, taxes, legal expense and 5 per cent depreciation on machinery and fixtures, real estate and stable inventory; all charges that cannot be applied to any specific order; helpers, blower expense, machinery depreciation, insurance, taxes, heat, light, power, small tools and supplies, proportion of pattern costs, casting cleaning and proportion of office expense; miscellaneous labor, miscellaneous supplies, expense on rejected castings, heat, light, power, insurance, depreciation on plant and equipment and superintendence; depreciation on everything

entering into cost of manufacture except direct labor, indirect labor, materials directly entering into product and incidentals which are directly connected with any manufacturing operation; all expenses of every kind except productive labor; fuel, fire brick, clay, sand, repairing tools and machinery, general repairs, general expense, teaming, oils, electric light, taxes, power, miscellaneous supplies, all foundry labor except molding and coremaking, general office expenses and accident liability.

The foregoing indicate that an earnest effort is being made by foundrymen generally to arrive at their overhead expenses, although it is evident that various methods are pursued and undoubtedly cost experts could point out many errors in the apportionment of the overhead expenses.

6.—In making an estimate what allowance do you figure for contingencies, such as haulage, special rigging, pattern repairs, rejections, etc.?

Only too frequently many of these items are overlooked in estimating the price of selling castings and unforeseen contingencies frequently arise which result in losses being incurred. One foundryman states that his product covers a range of material from castings weighing three tons each to rough, light hardware, so that allowances for contingencies, etc., must be based on practical experience and are different in every case. He added that on the accurate gaging of these expenses the success of most foundrymen depends and he considers this one of the most important items in estimating the selling price. Another foundryman replied that these items enter directly into manufacturing expense or overhead, with the exception of rejections. As he is engaged in the automobile cylinder castings business, the rejections are higher than normal, which are included in the defective castings record and are charged after the overhead is computed. In another instance no allowance is made for any of these items unless new patterns or special rigging is required, in which case the actual cost is borne by the customer if a small order, and is absorbed either wholly or in part by the foundry in the case of a large order. Other replies briefly are as follows:

Make no allowance but make the price high enough to include any special hauling required; in making an estimate we approximate as closely as possible the actual cost to us of haulage, special rigging, etc.;

no special rule, when competition is keen, the margin is close; items included in overhead generally, but we take into account the cost of special rigging and in the case of especially difficult and intricate work we make additions to cover the extra cost and liability of rejection; it differs on each job according to the class of work; covered in overhead expenses; 10 to 20 per cent; included in the overhead; 2 to 12 per cent; 7 per cent on hand molding and 15 per cent on machine molding; all included in overhead except rejections, which are figured by percentage according to the individual job; no contingencies are figured for hauling, special rigging and pattern repairs and if such are needed, the costs are figured in the estimate; the amount allowed for rejections depends entirely on the class of castings and is usually estimated by the superintendent; make special allowance for each item; pattern repairs are charged to customers and a certain percentage is added to every estimate for rejections, the amount depending on the class of work; where special rigging is necessary, the actual cost of labor and material is charged to the job, while haulage and other contingencies are included in our overhead; special rigging, haulage and pattern repairs are included in foundry overhead expenses; 40 per cent; 5 per cent; 25 per cent is added to cost of labor and materials; about 3 per cent of direct labor for special rigging and pattern repairs and an average of 18 per cent for rejections; carried in allowance for profit; estimate contingencies as closely as possible, based largely on previous experience; special rigging is added to the estimate, but other contingencies are taken care of by the burden; inward cartage is charged to the cost of materials, outward cartage is a sales expense and is charged to the same and we accept only long runs of work, rejecting all short runs requiring special rigging.

Pattern repairs other than sandpapering or shellacing are charged to the customer, while rejections vary, but should not exceed 2 per cent after the goods have left our hands; freight and pattern repairs generally are charged direct to the customer at cost; we add $1 per ton for hauling and usually 2½ per cent for special rigging; haulage is charged direct to material which shows up in the pound price of material; shipping is charged direct into a separate sub-division showing up in the pound price; special rigging is charged in a sub-division to the job order on which it is used; pattern repairs are charged into repairs pattern sub-division; rejections from the foundry are covered by a foundry scrap percentage and from customers into a reserve account known as "customers scrap."

7.—What percentage of profit do you estimate on each job?

This proved to be an exceedingly difficult question for most foundrymen to answer, owing to the fact that competition to a large extent governs the amount of profit that can be obtained. One foundryman stated that he endeavors to obtain 20 per cent, but frequently he found competitive conditions such that a larger profit could be obtained on some jobs while on others the profit had to be greatly reduced. Based on figures of his annual business, he found that the profits varied from nothing at all, or even a pretty stiff loss to 25 per cent during

an exceptionally good year. Another foundryman stated that he does not estimate any particular percentage of profit on each job since the overhead figures are on the safe side to the extent of from 3 to 5 per cent, and then is estimated a profit varying from 5 to 15 per cent, depending upon what the job is supposed to carry. One foundryman operating a large plant in the west replied that he has what is known as a critical output below which he cannot cover overhead expenses and up to this critical output business will be taken at cost rather than turn it down. Above this critical output from 10 to 30 per cent profit is figured, according to the size of the job and the state of the market. Another foundry engaged principally in the production of heavy work figures a fixed amount of profit for each molder's daily output, regardless of what it is. The majority of the replies indicate that the foundrymen endeavor to obtain a profit varying from 5 to 50 per cent and a fair average would be 20 per cent. Also the practice varies in figuring the profit for light and heavy work. However, many of the replies point out that while profits are figured, nevertheless in the stress of competition they frequently are entirely overlooked.

8.—Does the estimated percentage of profit vary on heavy and light work?

Opinions differ widely on the percentage of profit that should be figured for light and heavy work. One foundryman states that it should vary and points out that most foundrymen consider heavy work the most profitable. This he claims is a fallacy as there is no reason why light work with modern methods should not be just as profitable as heavy. However, another foundryman states that one general percentage of profit should be figured regardless of whether the work is heavy or light.

While there is no uniformity in the practice of estimating the percentage of profit on heavy and light work, the majority of replies point out that the profit varies, the larger profit being figured for heavy work and a smaller profit on light work. On the other hand, several foundrymen insist that the

same percentage of profit should apply on both light and heavy work. While some foundrymen estimate a larger profit on heavy work, others demand an increased profit for light work and the replies indicate no uniform practice among foundrymen in estimating the profit on castings of varying weights. This is a feature of selling price estimating that should receive the careful attention of the cost committee of our association.

9.—How do you estimate the labor cost on a job and what do you include in this estimated cost?

One of the unknown quantities in estimating the price for new work is labor cost and the replies indicate that this cost is estimated largely by experience and past performances on similar work. The majority of the replies pointed out the method of estimating the labor cost after the job has gone through the foundry, but this information was not sought. One foundryman stated that his estimate of labor cost on a job is obtained from the foreman and superintendent, who figure on the number of hours it will take to do the work and an effort is made to be on the safe side. In this estimate are included the cost of coremaking, helping and molding and this generally is figured in cents per pound and is added to the other charges. After the job is completed a rough estimate is made to see how closely he approximated the original figures and in time this will give a fairly accurate idea of how close these figures are being made. Another foundry replied that the labor cost is estimated by comparing the job with similar jobs previously turned out. In one shop the labor cost is estimated by the foreman after consultation with his assistants and includes the actual labor of molders' and helpers' time only, being figured at a rate which includes the time spent in pouring. For example, a man to whom $3 per day is paid would be figured at the rate of 40 cents per hour for actual molding time. In another shop the labor costs on all jobs are estimated from piecework rates furnished by the superintendent of the foundry made up by him covering the jobs. The molding, cleaning and machining, core and annealing costs are included in these labor figures.

The interesting practice in one shop is to determine the amount of time required and to double it to cover overhead expenses.

10.—How do you estimate the cost of molten metal in the ladle?

Estimating the cost of the molten metal individually is a practice not pursued by many foundrymen, although one explained his method in great detail as follows: "We go on the assumption that the molten metal is delivered into the ladle as though it came from some outside shop. This cost includes the cost of the metal in the yard on the basis of the particular charge being used at that time and to this is added a general average coke charge based on the yearly purchase of coke on the basis of the coke ratio, and to be on the safe side, we figure about 5:1, although our cupola practice is better than this. We figure lining on the basis of the material required during the year for this work and then figure the power required to operate the cupola, adding floor, elevator and all labor in connection with handling iron and attendance during melting. We figure a depreciation charge and repairs actually based on the value of the apparatus for doing the melting, which is aside from the general depreciation in the rest of the shop. The loss is figured on the results of many experiments and includes loss of metal through slagging, spills, etc. Another loss is added to cover the difference in the value of the metal going into the cupola and the scrap made in the shop and this is charged against the cost of melting. All of these items are added and divided by the average tonnage from which the general cost is established."

The replies indicate that the majority of the foundries have fairly accurate methods of obtaining the cost of the iron in the ladle, although in several instances merely the cost of the iron, scrap and fuel are considered, no allowance being made for melting losses, etc.

11.—Do you base your estimates on data previously obtained from your cost system?

This inquiry was made for the purpose of ascertaining to what extent foundrymen have installed cost systems and with

only few exceptions, they replied that the estimates were based on such data.

The foregoing indicates that foundrymen generally realize the necessity of making proper estimates, yet the absence of some standard system or formula makes it practically impossible for any two foundrymen to arrive at approximately the same quotation of new work. It is apparent also that estimating schools established by several trades would prove of value to foundrymen generally and the consideration of such a move is earnestly urged upon the cost committee of our association. Furthermore, the time available for the consideration of these replies made it practically impossible to summarize the large amount of valuable information that can be obtained from them. It is suggested that the cost committee pursue this investigation further with a view of establishing a standard formula for estimating the selling price of the foundry output.

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Scientific Management in the Foundry

By Frederic A. Parkhurst, Detroit.

1. As a general proposition, the foundry offers neither more nor less in the way of difficulties to be overcome when installing scientific managment, than do other lines of business. There is no hard and fast rule to be followed. Each case, each kind of business and each different plant presents its own peculiar problem. On the other hand, the possibilities under scientific methods are greater in the foundry than perhaps any other metal industry. The following will be confined entirely to the author's personal practice and experience.

2. In the early stages of reorganization work there are many preliminaries to work out. Many of these affect those "higher up." The study of the personnel is in itself a task not to be lightly considered. After these are many problems which cannot be even approached until the co-operation of certain individuals is assured. It would take a good size book, perhaps more than one, to cover this one phase of the many things the organizing engineer has to contend with. The space here available will not permit of a discussion of the whole subject but special attention is called to the two following general subjects, *2* and *3*.

2—Office and Shop Personnel

3. Too often the office personnel has a tendency to imagine that they have special privileges that are not to be accorded the shop employes. Because their particular specialty gives them a shorter work day they should not take advantage of that fact. They should realize that they have greater obligations to their employer than any other employe.

4. The obligations of the office man are greater because as a class he is of better education, and has greater individual responsibility. He is often in possession of a vast amount of valuable information, all of which is the property of the firm. It is not his own. He must do his work and fulfill all the

functions of his position with absolute impartiality. He must not let personal likes and dislikes in any way influence his relations with those with whom he comes in business contact.

5. Office operations as a whole are handled fully as inefficiently as are shop operations. In fact some of the marks of "efficiency" are even lower than can be found in the shop connected with that same office. Very often the inefficiency of the office man will prove much more costly to the firm than will a comparatively low mark in the shop end.

6. Another point not to be lost sight of is that the less educated and more limited shop man is very prone to follow the example set him by his superior, or those occupying higher or more lucrative positions. It can be seen how far reaching "higher up" inefficiency may prove.

7. The shop employe is smart and he who takes him for a fool, "fools" himself. The office, including the planning room, (which is the real brain of the shop organization) must in itself be most highly developed and efficient before maximum shop efficiency is possible. Likewise, a business which is all office departments, offers all the opportunities for scientific management that can be desired. Such a business must eventually adopt such methods to compete successfully in its particular field. (See Fig. 1)

8. In definitely placing the responsibility in thoroughly defined organizations, such as that being described, it is important that individual feelings be considered. In other words, although discipline may be strict all investigations should be perfectly impartial and justifiable. No manager ever lost any prestige by any decision which he was forced to make, provided he was perfectly just and based such decision on unquestionable facts.

9. If there is one thing which will disrupt an organization quicker than any other, it is the habit of tale bearing. Criticising one man to another particularly when you are talking to subordinates is equivalent to the same thing, subordinates should not be allowed to carry tales or pass criticism about others. Of course, the management should be governed by exactly the same policy. As stated in the earlier part of

this article, the shop man and the rank and file are great imitators. They are very prone to follow the examples set by their superiors.

10. A great deal of harm has been done by thoughtless criticism on the part of men in authority, especially when directing these criticisms against their superiors. Talk of this kind is more or less injudicious and always has one effect—that of disrupting the best organization that was ever developed. The fact is often lost sight of that a company's policy and

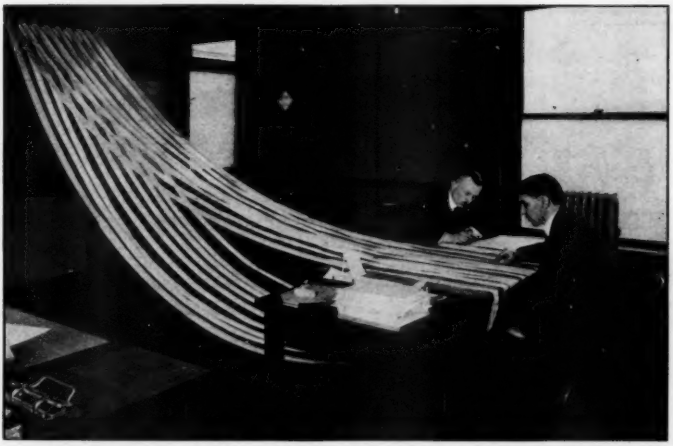

FIG. 1—APPLYING SCIENTIFIC METHODS TO OFFICE WORK
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very often specific orders are *apparently* open to question. On the other hand, were all the facts known which led up to the establishment of this particular policy, or the issuance of that order, perhaps the person criticising the same would have an entirely different understanding.

11. Methods of scientific management are based on certain well defined principles. As first stated, the method must be suited to the local condition and the particular problem in hand. Without too much general discussion it will be well to briefly outline the few chief elements necessary to maximum shop

efficiency (hence production), maximum prosperity to the individual and low costs. The realization of these conditions must result in placing the firm, employing these methods, in position to develop an enviable position in its particular field. It will be in position to compete fairly and successfully for its business. It can also hold the esteem as well as the business of its customers; all because of service, quality, price of its product and reliability of deliveries. These conditions cannot otherwise be fully realized.

3—Sales Department Development

12. Comparatively early in the period of transition from the old to scientific management, it is necessary to prepare for the development of a highly efficient sales department. This department is the business getting machine which makes possible the greatest shop efficiency. It must be up to date, efficient in itself and properly articulated with the shop organization. The kind and size of a business, existing competition, probable future growth, and the plant and plant organization which is to support the work of the sales department, are all vital factors to be considered in its development.

13. The speeding up of the sales end presents many peculiarities of its own. For this reason it is important to consider sales expansion as early as possible. We must consider the sales department as the business getting machine. Though our plant under the old methods may be overworked, it is more than likely to be running far below capacity when all departments are operating efficiently.

14. The demand to be put to the business getters of an organization when the producing plant (or plants) become highly productive, are seldom, if ever, realized by the former as early as would seem natural. Very often the sales department seems loth to admit the possibility that they themselves need speeding up. Arguments are often put forth when their department is approached, to the effect that "the shop needs tuning up," not they. Also to the effect "that when the shop can get more efficient and when it can deliver the goods somewhere near on time, then and then only will it be time to worry about us."

15. It is perhaps natural that this attitude often exists. Read the files containing innumerable complaints from customers—deliveries months overdue and quality way below par. Other common and by far too numerous complaints are emergency orders seemingly ignored and profitable work in the customers' plants tied up for want of parts, shipments ordered by express go forward by freight, too much delay after getting an order in finding the specifications incomplete, time lost in much correspondence to settle details to enable the shop to proceed; this delay by the way often is up to the customers. To cap the climax it often happens that the order long delayed has been incorrectly filled. These and many more familiar examples can be quoted to support the complaints of the sales department referred to above.

16. Before proceeding further it may be well to go into the all important matter of quality, both as to workmanship and material. Modern business is demanding more and more in this respect. It is a factor which is becoming more important daily. Combined against by quality and reliable promises as to delivery and service, price often has to take secondary place. (See sections *17* and *23*).

17. With a highly organized and efficient plant, price, though important, is no longer the sole controlling factor. If a customer can be assured of quality first and reliable and adequate deliveries, he cannot afford to patronize the lowest bidder who cannot win his confidence in regard to the first two factors. Scientific management does not, however, realize for the owners of a plant so run only high standards of quality and schedules of shipments as regular as the train schedules of our best railroad service. It goes further and gives the lowest and most reliable cost to the producing plant; hence the *lowest* prices can also be quoted with the assurance of a fair profit as well.

18. Unfortunately we cannot await the fulfillment of the prophesies in the last two preceding paragraphs before undertaking the "tuning up" of the sales department. Therefore, as previously stated, this department cannot be blamed too much if not over-enthusiastic at the attention about to be bestowed upon

it. To wait too long, however, is costly for several reasons. The improvement in shop methods is slowed down and often in danger of total collapse unless plenty of work is always available for men and machines. This is particularly true at certain critical stages in the organizing engineer's work. Take for example the preliminary work prior to realizing intense production and the payment of bonus. This is difficult in the extreme, even under ideal shop conditions and with plenty of work.

19. When the shop has but little to do and the men are working from hand to mouth, so to speak, it is a long, tedious and delicate problem to handle. It may at times be even a hazardous undertaking. We are all human; under unfavorable conditions the workman is not going to work himself out of a job (as he believes) by high output no matter what he is paid, if he can help it. Though it takes from one to several years (generally the latter) to realize maximum shop efficiency, the improvements in shop conditions will be felt much earlier. The sales department must therefore begin to extend itself much earlier than the layman may realize. This is true for several reasons.

20. Doubling the capacity of a plant by putting it under scientific management is not unusual. In fact, it is a conservative estimate which can easily be proved by the reader. This condition the sales department must meet by providing double (or more if the selling price is less) the amount of orders, or else productive plant is forced to die idle. If this happens an undue proportion of "over-head" enters into the total cost of the product actually turned out. Will the sales manager welcome this extra charge if added to his cost of selling? No! but with business to be had, where else does it rightfully belong? There must be a maximum limit of overhead that can be rightfully charged to costs. This must be based on a fair normal production. A greater overhead due to lack of business is a distinct operating loss.

21. If we realize a greatly increased production and a lower net selling price, as we surely will do, we may naturally expect a greater demand for our product. Competing firms may at

first cut prices temporarily. Whether they can stay in the race or not does not alter the fact that the sales department under discussion must be in position to meet this extra activity of the competitors—legitimately, of course. The above statements must not be construed as necessarily advocating the reduction of prices.

22. Other changed conditions too numerous to mention, some local and others due to changed shop conditions, growth

FIG. 2—PLANNING ROOM
Paragraph 26

in volume of business, etc., further affect the methods to be employed in modern selling. Each individual case must of course be diagnosed and treated individually as to detail; don't wait too long.

23. To meet changed operating conditions and a plant capacity two or three times the figure once considered 100 per cent capacity, the sales department must prepare to supply a larger volume of business as time goes on. The support of a

well balanced organization, backed by prompt deliveries and low costs (the latter permitting of lower selling prices) all help to promote larger sales. Early in the change of conditions this fact will not be easily recognized by the sales department. As time goes on, however, the sales department will be in position to utilize highly efficient shop methods as an important selling factor.

24. The sales department too often has much to contend with through customers' complaints caused by an inefficient plant. The shop organization is slow to realize this fact. When shop conditions and methods so shape themselves that the old time troubles disappear, there will soon be developed the closest harmony between customer, sales department and the operating end.

25. Scientific management throughout the entire organization has a far reaching and ideal effect. This condition is also felt by the customer. The customer's schedules and source of supply give him no trouble. His confidence is strengthened and he is perfectly satisfied. After all is said and done, satisfied customers are the keystone of the arch that supports any business.

4—Functions of the Planning Room

26. Briefly the functions of the planning room (See Fig. 2) consist of—

27 a—The minute analysis of each order into its constituent parts and the routing of all its many operations.

28 b—The control of purchases and all material in storage as well as that in process of manufacture; also the sequence of operations according to a predetermined schedule. Material standards.

29 c—The control of equipment and tools.

30 d—The control of methods and determinations of standard operation times, including the distribution of help and the "balance of labor".

31 e—Control and standardization of wages and bonus based on individual efficiency.

32 f—Analytical costs and accurate data for estimates, including departmental indirect expense, thus making it possible to practically predetermine costs.

5—Analysis and Routing of Orders

33. As soon as an order is received it must be examined in the sales department. If correct as to specifications, price, terms, etc., it should be approved and passed to the produc-

tion clerk in charge of the planning room. He will examine it and check up the specifications to see that it is sufficiently complete to allow of its proper routing to the shops. It is essential that each order have the date of completion specified. If shipments are to be made at a certain rate per month this should be clearly stated. It is not sufficient to call for completion "at once," "hurry," or "rush." These terms mean absolutely nothing; they can be only comparative.

34. The next step is to record the item on the production card. This card is a general record or history of that particular pattern. Every order for castings from one pattern is recorded on the one card. As soon as the work is in process the daily history of the job is recorded. This history includes;

35. 1.—Total castings made each day.
2.—Number of defective castings each day.
3.—Net good castings each day.
4.—Total good castings made to date.
5.—Total castings shipped to date.

36. This card has capacity for eight months, at the end of which time a new card is started and the first one filed in a transfer file.

37. After the production card record is started, the order is passed to the route clerk. The route clerk issues the necessary "work orders" to each department in which any work is to be done. These work orders are issued to cover specific operations. If the pattern has 25 different core boxes a work order is made out for each core box and for the total number of cores required from the box, twenty-five work orders. The mold room receives a work order for the number of castings required. The work order also specifies the number of men to work on the job. Work to be done in other departments is treated in a similar manner. The work orders are issued in duplicate; one to the shop board and one to the planning room board.

38. As a guide to routing work in the core rooms the route clerk has a "standard core routing record." This record shows the number of each core box, the name of the core, the bonus chart number for each core and its nominal standard routing. For example, if the standard routing specified is 1C1 it is

XUM

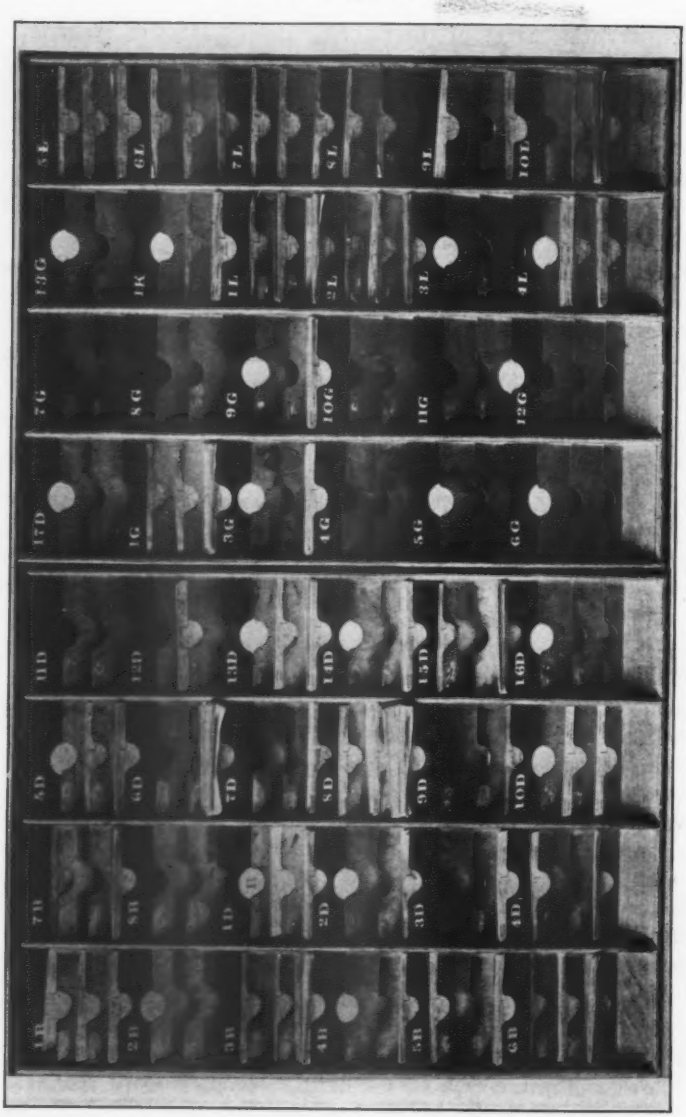

FIG. 3—DETAIL OF ONE TYPE OF PLANNING BOARD
Paragraph 39

understood to mean that any bench from 1 to 10 inclusive, in number 1 core room (1C) can make the core.

39. In further explanation of the above it should be noted that the coremakers, as well as other employes, are divided into grades, generally three. In the core rooms, as a case in point, one grade of coremakers work at benches 1 to 10 inclusive; another grade at benches 11 to 20 inclusive and the third grade at benches 21 to 30 inclusive. To distribute the work to advantage the route clerk has but to glance at the planning board to tell what bench in any grade is available. (See Fig. 3). If all benches have work ahead, or if but a given number are in operation, he issues the work order to the bench having the least to do in that grade.

40. Of course, there are special instances whereby the above routine may be departed from. The method is perfectly flexible. The conditions are so under control that it takes but a moment to tell the correct routing of any job. The same general scheme is used in routing work to other departments. Machine work should be routed directly to the machine; symbols are used exclusively as a means of identification. Section 8 will give some detail as to how the symbol scheme is developed and used.

41. Scientific routing of work in process tends to eliminate many false moves and generally expedites the movement of material through the shops. It is necessary to route work specifically by operations; else the control of it from the planning room is impossible. It will be seen that this method practically eliminates the foreman as a factor in distributing work in his department. Routing is developed as a specialty under scientific management. One man, the specialist, soon becomes more competent (with the aid of the planning board) to distribute work than the best foreman. This method also has quite a value as a cost reducing factor. The balance of work on hand, separated into its various grades is always *immediately* available. This makes possible the control of the labor *necessary* to be expended daily to handle the work actually in process, and only in the *required* amounts. This will be further referred to later.

XUM

FIG. 4—FACTORY BOARD IN SESSION
Paragraph 44

6—The Control of Material and Operations

42. The order-of-work clerk is responsible for the processing of work according to schedule. To assist him in this work, it is necessary to maintain several schedules. This part of the work is done by the schedule clerk. The schedule clerk also assists the order-to-work clerk in following up operations. He advises as to the status of work in process not coming through in accordance with the predetermined plan.

43. The process schedule is made out after the issuance and routing of each order. Some of the planning of the various operations is done exclusively by the order-of-work clerk. Other factors affecting the order of processing must be determined by consultation with the superintendent, foreman, time study foreman and others. To properly control work in process, frequent conferences are necessary. To this end the factory board is brought into existence.

44. The factory board is generally made up of the organizing engineer, superintendent, mold and core superintendents, production clerk, time study foreman and the order-of-work clerk. Meetings are held daily except Saturday if it is only a half day, otherwise six days a week. (See Fig. 4).

45. All important matters affecting the general management of the shop are brought up at these meetings. The general orders are gone over at frequent intervals. Deliveries are planned in a broad way. Departmental work is also taken up in more or less detail, depending of course on the condition of work in the various departments.

46. One important matter to receive attention daily is the analysis and study of the production report for the previous date. Unusual losses due to defective castings, lack of material (especially cores), or faulty equipment, are taken up in detail. Costs for the previous day are also given most careful thought The cost of all the different classes of castings made the day previous is known each morning by 10 o'clock. This is an important controlling element. Knowing the cost each day makes it comparatively easy to remedy a condition resulting in a higher cost; likewise, it is easy to take full advantage of a low cost condition.

XUM

47. It is at these meetings that the order-of-work clerk takes up many of the matters he must settle to bring his work in process through on schedule time. Such planning is most important; without it a railroad like schedule cannot be maintained. The frequent change of shipping specifications on the part of a customer is one of the very frequent occurrences. Yet even this is not so serious in a shop run under the methods being described. With all factors under control a radical change in the shop schedule can be made, and is continually being made, without serious handicap to the general efficiency of the shop.

48. When shop schedules are under control, the customer is able to work to a closer schedule himself than if he had to make larger allowances for failure on the part of the foundry to meet its shipping promises. The result of this condition is to reduce to a minimum the change of schedule on the part of the customer. His confidence in his source of supply materially helps both parties. He also reaps material benefit in dollars and cents due to less capital invested in work in process.

49. The preliminary work necessary to get a job under way must be given careful attention and vigorously followed up. The proper preparation of pattern equipment, including its rigging up makes an enormous difference in the delay (and hence the cost) of getting a new pattern up to maximum production. The planning of the preparatory work and the making of the first few samples often requires the combined knowledge of all the factory board. This part of the schedule is the most difficult one to intelligently plan and bring through on time. This is the part of the work that gives the order-of-work clerk the most trouble. It is also the part on which he must rely in a large measure on the assistance of others, especially the pattern foreman and equipment boss.

50. At times the shop schedule has to be planned after the above mentioned preliminaries are worked out. This is especially true in cases where the equipment is furnished wholly (or in part) by the customer. At any event, the correct preparation of a job may be considered as the one greatest step toward its

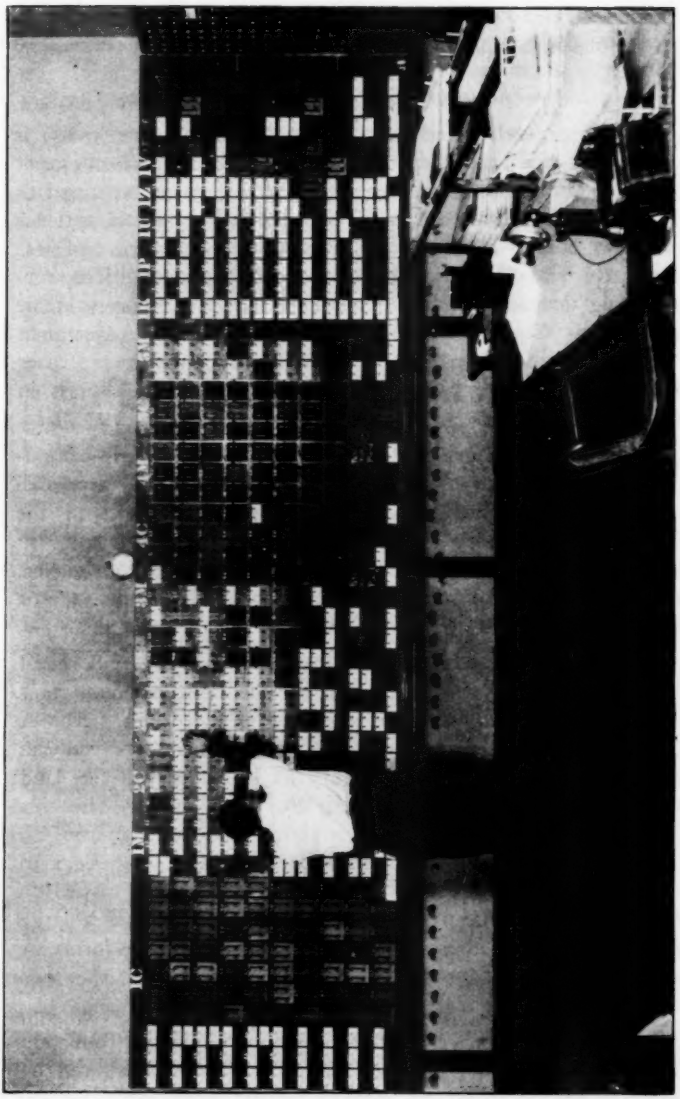

FIG. 5—PLANNING BOARD
Paragraph 50

successful completion. The control of the subsequent shop operations is comparatively simple. (See Fig. 5).

7—The Control of Plant and Equipment

51. In general, foundry equipment (including small tools) is found in a poorer state of repair than obtains in the majority of the other trades. The reason for this may be explained as follows. The equipment itself (except perhaps metal patterns and core-boxes) is as a class rough in appearance and less expensive in construction. The general shop conditions surrounding its use tend to further make it appear less valuable than it is. There are few finely finished parts. Adjustment features are too often over-looked entirely; and in some cases the maker through his design seems to invite carelessness in this respect.

52. The real cause for the average low standard of efficiency that is found in foundry apparatus, is directly traceable to the large percentage of unskilled help employed in the operation of foundry machines. They are not mechanics in the sense we consider a machinist, pattern maker or tool maker, though perhaps competent enough as far as the "technique" of their own particular work is concerned.

53. A careful study of these men at their work will reveal a deplorable ignorance of the use of the most common tools such as a hammer, wrench, spanner, screw driver, etc. A crow bar in a foundry is often a scarce article, yet you can walk through the average foundry as often as you like and seldom fail to see the shovel doing duty in its stead. The uses to which foundrymen can put a shovel are too numerous to mention: hence, a great expense for shovels. It is easier to knock the handwheel off of an air valve and leave it turned on full blast than to keep shutting it off. Here we find a large waste of compressed air, one of the most expensive forms of power.

54. Now molding machines are as a class expensive enough when in good operative condition and not tying up production because they will not operate. But when they are abused by ignorant help, allowed to become clogged with sand, fed by

leaky air lines (caused by improperly clamped or cut hose), inaccurate in operation due to worn parts, resulting in shifts or "torn up" molds, we then find an enormous direct and indirect loss of many dollars each day they are in use.

55. The loss due to faulty machines and tools is far reaching. Losses of production, sometimes involving many men is a big item in itself. Add to this the loss in profits on a realizable production you don't get. Also consider power wasted, interest on expensive patterns, non-productive plant, increased defective loss and it seem we have too much already. One more even greater item must be included however, before our list is complete; viz: the moral effect of such a condition on all the men employed.

56. To prevent all of these losses requires constant care and close inspection. An ounce of prevention is worth a pound of cure. A maintenance force of skilled mechanics is apparently an expensive luxury. In net cost however, such supervision is one of the biggest investments. It is just as important to keep foundry equipment operative as it is to take good care of the machines in a first-class machine shop. Motors particularly soon give trouble due to the excessive dust always prevalent to a certain extent, no matter how well the work rooms are ventilated.

57. The maintenance foreman should be considered as important in the foundry as he is in business. Give him sufficient help, put him in charge of all the equipment and hold him directly responsible for it. He must keep in close touch with all conditions affecting the operation of machinery and have the authority to make immediate repairs as fast as the first indication of such a necessity presents itself. Anticipation of such a condition is necessary. Don't wait until it develops into a *real* trouble.

58. When equipment is finally whipped into shape and the methods bring practically all employes under bonus, it will be easy to maintain machinery in first-class condition. As the workman is principally engaged to operate (not repair) equipment, he should not be expected to waste his time and the firm's money doing work that he is not fitted for.

59. Before leaving this part of the subject, attention should be called to the care and operation of core ovens. Here we have equipment which if slightly out of order will greatly increase the cost of drying cores. Forcing the ovens will result in burned cores. Improper drying results in damp cores; and "blown" cores spoil castings. Not enough cores ties up production and we are back again to the subject of limited output.

60. Pyrometer control of oven temperatures means not only a saving in fuel, but a greater saving due to "even" drying, fewer burnt cores and minimum delay in getting cores through the ovens. Here again we have the advantage of periodical inspection and repairs *before* trouble begins.

61. Accurate data on oven duty will divulge many sources of loss in efficiency. The time study will show a wide variation in the time it takes to dry one core as compared to another.

62. Proper maintenance and frequent inspection of equipment effects another even greater saving, greater at least from a humanitarian desire to reduce to a minimum the chance of serious accidents. Many comparatively recent laws tend to greatly promote the care and guarding of machines. These laws are in themselves insufficient. We need local care and minute supervisions.

63. We must not leave the workman entirely to himself in this respect. Some men are notably careless and reckless. It is part of their nature. Such men are not protected under the new laws, "contributory negligence" or the natural hazards of a trade being no longer a defense for the master. From the foregoing it can readily be seen that all the planning and supervision we can bring to bear on this subject is more than "worth while." The proper care and safe-guarding of gears, belts and wheels should be the special care of a functional boss. It will be cheaper in the end, the psychological effect is great and the net results obtainable from a given plant will be much larger. It will be *producing all of the time.*

8—Symbols

64. The prime object of any system of symbolizing is to provide a character which will assist in the prompt identifica-

tion of any unit. The second object is to use a character flexible enough to include all branches of a business within its scope. The present opportunities for the use of a practical, comprehensive scheme of symbols are limited.

65. The author maintains, adverse criticism to the contrary, that a symbol is an identification mark first and foremost. The character must positively differentiate one article or unit from some other. If a simple and not too cumbersome symbol could be devised which would instantly tell by its form or character what is represented, it might be ideal, but so far all efforts along such lines have proved impractical. If we know the number of a house on a given street, for example, 360 West fifty-ninth street, it is not necessary to know whether the house is an old mansard design, an early colonial type, or a modern tenement structure in order to identify it. The address enables us to direct one to this house or find it ourselves with a minimum of effort. The symbol should enable one to identify an article or unit with just as little effort. So, bearing in mind the essential factor of identification, it is obvious that the greatest practical use will be obtained from that scheme of symbols which is founded upon the simplest rules, with as few characters as possible and which has the least variations.

66. The different schemes of symbols which have been developed from time to time may be classed under the following general headings:

67.
1. Dewey Decimal System.
2. Mnemonic System.
3. Arbitrary System. A modification of this might be called the Group System.

68. The Dewey Decimal System is undoubtedly the most complete and highly perfected in theory of any, and, as the name indicates, is a combination of figures and periods giving a symbol of an almost unlimited number of characters. This use of figures and decimal points offers an infinite number of possible combinations. The system carefully worked out will provide a number symbol applicable to every conceivable thing past, present or future. It is, however, in no way suggestive nor practical for general use, and a voluminous key is necessary even to interpret the symbol.

69. The Mnemonic System, as its name indicates, was devised with the purpose of supplying a symbol which should be suggestive and which would indicate the object that it was intended to identify. In theory it is an excellent system and could, perhaps, be applied in a limited way to a comparatively small number of units so as to be comprehensive and valuable. For general use, however, the system utterly fails to meet the end for which it was designed. It is impossible to devise a symbol on the mnemonic plan which is generally applicable to units of widely varying kinds of business. The mnemonic symbol consists of combinations of letters and figures with the occasional use perhaps of a period or a dash. If the attempt is made to apply this system very generally, it soon becomes apparent that the result is a symbol of a great number of characters, sometimes running to twelve or fifteen, and one which in itself is in no way suggestive. Again a voluminous index or "key" becomes necessary.

70. There are a great many combinations of letters representing general classifications which have been developed in connection with the mnemonic symbol system. The result is that five, six or seven letters, or combinations of letters and figures, may be necessary before one gets to the number identifying the one particular piece in a class from its next-door neighbor. A further disadvantage of a mnemonic scheme is that a combination of letters and figures is much harder to write, read or remember, even for a few minutes, than a comparatively arbitrary one, providing this combination of letters and figures consists of more than several characters SHVXRI is much harder to read and to retain in the mind than 24321X or 243211. If two pieces just alike are symbolized, one with the first of the above symbols and the other with the latter, the one bearing the plain number can be more easily and quickly identified.

71. Another argument often brought up by advocates of the mnemonic system is that when one sees a piece bearing a symbol or sees the symbol in print, it is desirable to know what the piece is so that it can be located. In practice, however, this is not so for several reasons. One is, that should a stray and strange piece with a symbol attached be found, it would

be necessary in any case to refer to the symbol index. This would be true whether the Dewey, Mnemonic or Arbitrary System was in use. Obviously, then, the simplest and easiest system to remember is the best.

72. In the majority of cases the use of the symbol is either in connection with papers or documents, or one is looking for a piece of which the simple name is known. Further to illustrate this point, suppose that the order or material list referred to a "Right Support for an 18-inches x 10-feet motor-driven engine lathe;" the simple name of the piece would be a support, which one would identify by its symbol. The symbol in this case answers the same purpose as a number of a house on a certain street. In practice, as above stated, it is very seldom that there is any great material advantage, especially in connection with piece symbols, in having the symbol represent the character of the piece involved. After all is said and done, this is an absolute impossibility without reference to an index.

73. Some of the most satisfactory and easiest forms of identification in use are some of the old systems of "piece numbers," which are nothing more or less than arbitrary numbers which have been given to pieces as they were designed or became merchandise. Another very old scheme is that of grouping pieces by classes, as E112, to represent a part number 112 for an "E" type machine. Modern practice, however, especially in connection with the higher developed forms of management, has made it desirable to utilize a scheme of symbols for many and various purposes. The writer believes that the simple and comparatively arbitrary form of symbol is by far the best.

74. The scheme of symbols, outlined below is an endeavor to illustrate to what advantageous use symbols can be employed. It also gives a key to a practical set of symbols which can be modified or expanded to suit any kind of manufacturing or jobbing business. It will be noted in studying these symbols that there is a certain element of suggestiveness about them as far as the different classes of symbols are concerned. (See end of article). The arrangement of the numerals, however, can be purely arbitrary, except that, of course it is wise to be always

systematic and try to symbolize in order of age, size, or alphabet, as the case may be. The scheme may be classed as a purely arbitrary one.

Departmental Symbols

75. Let us assume that the first set of symbols will be used to represent departments. Bearing in mind that it is desirable to have as few characters as possible in the symbol, let us start by arranging the departments in their general order, working from the administrative heads down to the manufacturing departments of the shops, and allotting a number and letter to each as follows:

Departmental Symbols Adapted for Foundry

76.

1A—Accounting Room
1B—Local Sales Dept.
1C—Core Room No. 1
2C—Core Room No. 2
3C—Core Room No. 3
4C—Core Room No. 4
5C—Core Room No. 5
6C—Core Room No. 6
1D—Delivery Dept.
1E—Employment Bureau
1F—Furnace Room (Class A and C)
2F—Furnace Room (Class B only)
1G—Garage
1H—Heat, Light and Power
1I—Inspection Dept.
1J—Janitors and Watchmen
1K—Carpenter Shop
1L—Planning Room
1M—Molding Room No. 1 (Class A)
2M—Molding Room No. 2 (Class C)
3M—Molding Room No. 3 (Class C)
4M—Molding Room No. 4 (Class C)
5M—Molding Room No. 5 (Class B)
6M—Molding Room No. 6
1N—Knockout (Class A and C)
2N—Knockout (Class B)
1O—Time Keeping
1P—Pattern Shop
2P—Pattern Storage
1Q—Sand Mixing
1R—Receiving Room
1S—Shipping
1T—Trimming Room (Class A and C)
2T—Sand Blast (Class A and C)
3T—Trimming Room (Class B)
4T—Sand Blast (Class B)
1U—Machinists

2U—Brass Finishing Dept.
3U—Tool Room
1V—Forge Shop
1W—Welding Dept.
1X—Stores—Metal
2X—Stores—Lumber
3X—Stores—Iron, etc.
4X—Stores—Miscellaneous
5X—Stores—Sand
6X—Stores—Oil
7X—Stores
8X—Stores
9X—Stores
10X—Stores
} Available for new Stock divisions
11X—Move Material Foreman
1Y—Yard Dept.
1Z—Maintenance Dept.

77. On this basis any letter of the alphabet preceded by a numeral indicates a department.

General and Departmental Expense Symbols

78. The expense symbol consists of the letter "X" (or "XX") followed by a numeral running from 1 up. The following list gives an idea of the general indirect expense symbols as they may be adapted to a foundry. As these items are items which can't be distributed departmentally but are general expense, we use the two letters "XX".

Symbols

79.

XX1	Salary of Managers, Superintendents (including Supt., Core Supt., and Mold Supt.)
XX2	Clerical Wages
XX3	Other Labor
XX4	Supplies
XX5	Maintenance of buildings and structures
XX6	Maintenance of equipment, furniture and fixtures
XX7	Care of
XX8	Miscellaneous Expense, not supplies
XX9	Miscellaneous small tools
XX10	Experimental and Test Expense
XX11	Fuel
XX12	See 1HX12
XX13	See IHX13
XX14	See IHX14
XX15	See IHX15
XX16	See IHX16
XX17	See IHX17
XX18	Advertising
XX19	Traveling Expense (operating only)
XX20	See IGX20
XX21	See IKX21

XX22 See 5CX22, 5MX22 and 2TX22
XX23 Injuries to employes
XX24 See IWX24
XX25 Inventory Expense
XX26 See LFX26
XX27 See 5CX27 and 5MX27
XX28 See IHX28
XX29 See IHX29
XX30 Freight and Express
XX31 Defective and damaged castings expense
XX32 All bad work expense exclusive of XX31
XX51 Legal Expense
XX52 Insurance, (Monthly Entry)
XX53 Taxes, (Monthly Entry)
XX54 Depreciation, (Monthly Entry)
XX55 Interest Expense, (Monthly Entry)
XX56 Metal Shrinkage, (Monthly Entry)

80. Departmental expense symbols consist of the letter "X" followed by a numeral. This symbol X1 and upwards is preceded in every instance by the department symbol. For example—1AX1 represents an expense symbol for department 1A; likewise 10X10 or 1PX5 indicates certain expense items for the departments indicated by the first two characters of the symbol.

81. It will be noted that the departmental items of expense cover exactly the same subjects, number for number, the only difference being in the departmental symbol preceding the letter "X". Some departments may not use some items required for another department. A typical list of departmental expense symbols is given herewith to indicate the sub-divisions. The list given below applies to five core rooms in one large foundry. A similar list is made out for each department listed above in the list of departmental symbols.

Symbols

82.

5CX1 Foremen's wages
5CX2 Clerical Wages (including shop time clerks)
5CX3 Other Labor
5CX4 Supplies
5CX5 Maintenance of buildings and structures
5CX6 Maintenance of equipment, furniture and fixtures
5CX7 Care of
5CX8 Miscellaneous Department Expense
5CX9 Miscellaneous Small Tools
5CX10 Experimental and test expense
5CX11 Fuel
5CX12
5CX13

5CX14	
5CX15	
5CX16	
5CX17	
5CX18	
5CX19	
5CX20	
5CX21	
5CX22	Sand
5CX23	Injuries to employes
5CX25	Inventory Expense
5CX26	
5CX27	Replacement of Stock Chills
5CX28	
5CX29	
5CX30	
5CX31	Defective and damaged castings expense
5CX32	All bad work expense exclusive of 5CX31

Order and Job Symbols

83. General orders and job numbers may be designated by allotting to each of the different classes a suggestive letter which is followed by a numeral representing the sequence of the order or job. The following classification is offered as a guide and to illustrate this point.

84. Orders are indicated from O1 and upward by numerals. In the event that it is desirable to divide the order into items, either to separate different kinds of work or to get subdivisions for cost or other purposes, each item should be identified by the addition of a small letter a-b-c-d, etc., depending on the number of items involved. For example, O1260a-d would indicate an order having four items, and each of these items would be known as O1260a, O1260b, O1260c and O1260d.

85. Contracts are designated C1 and upward by numerals. Should a contract be subdivided into four items, as above explained for orders, the contract as a whole would be known as C1260a-d and the several items identified by the small suffix letters in the same way as order items.

86. Stock is marked L1, L2, etc. Stock jobs would only be issued for one or more pieces of a kind on which individual costs were to be obtained; in every case stock jobs are only made for stock.

87 Miscellaneous is indicated by M1, M2, etc, representing jobs for merchandise, etc., built for some specific order, but which may be divided before completion to apply on some customer's order other than the one on which they were originally started. These jobs may be divided into items, as explained above, for (O) and contracts (C).

88. Plant is indicated by P1, P2, etc. These jobs are only used for work for plant and for some specific equipment which is made as a whole on one plant job. As many plant jobs are issued as are necessary to get the required individual record of their cost.

89. Factory is indicated by F1, F2, etc. F jobs are handled exactly as are plant jobs—see preceding paragraph.

Plant Equipment

90. A very common and satisfactory system of symbols for plant equipment is one composed of a letter followed by a numeral suggestive of the kind of machine or tool to which the symbol applies. In some series of symbols it may be desirable to have the numeral follow the letter rather than to precede it, so as to clear other existing sets of symbols. There is no further particular reason for using one method instead of the other, though it is surely more correct to say "lathe 5" (Symbol L5), than to say "5 Lathe" (Symbol 5L). Both methods are in extensive use and answer the purpose. Arbitrary numbers for machines systematically arranged answer every purpose, as they also do for piece symbols. To identify equipment in each of several plants run by the same company, a plant letter may precede the equipment symbol. DB11 would indicate boring mill 11 in Detroit and plant or CB11 would indicate boring mill 11 in the Cleveland plant.

91. By combining the machine symbol with the symbol of the department in which the machine is located, we have a very complete and suggestive scheme of symbols which will not only identify each machine by type, but which will also show at once where it is located.

92. Machines (and other tools) are ordinarily grouped as follows:

93.

B	Boring Machines
D	Drilling Presses
G	Grinders
K	Keyseaters
L	Lathes
M	Milling and Gear Cutting Machines
P	Planers
S	Shapers and Slotters
V	Vises
W	Woodworking Machines
Z	Miscellaneous Small Tools

94. In developing a symbol on this system, 1PW1 would indicate a woodworking machine, No. 1, located in pattern shop; or symbol 1KW6 would indicate a woodworking machine No. 6, located in the carpenter shop; or 1UM12 would indicate a milling machine No. 12, located in the machine shop.

95. It will be noted in the examples just cited that a character is made up of a letter followed by a numeral to form one symbol, which added to the symbol for a department makes a combination symbol, giving us a direct reference, not only to the piece but to the location as well. There will be no other similar symbol so that we have no possibility of duplication or confusion.

96. By referring to the list given above, it will be seen that Z is a characteristic letter for miscellaneous small tools. This classification also includes forged tools for lathes, planers, boring machines, shapers, slotters, etc., but ordinarily it would not include standard commercial drills, taps and reamers. From the standard grinding charts for the tools mentioned as belonging to this Z class, they would be numbered systematically as far as possible, but later arbitrarily. This number, of course, following the letter Z. As many of these tools will have a drawing, the symbol will be constructed as explained below for "Pieces"; as an example, D-Z 164. The D indicates the size of the drawing, Z that it is a tool and 164 its number. This number can be followed by the symbol 3U the symbol for tool department—in cases where it is desirable. Theoretically, at

least, all of these miscellaneous tools belong to the tool department and are checked out from there to the men and machines.

97. To illustrate further the advantage of such a system of symbols in connection with expense accounts, the following example is given. As explained in a former paragraph, subdivisions of departmental expense would be indicated by an X symbol following the departmental symbol; 1U stands for machine shop, and if the subdivision of this departmental expense for miscellaneous repairs or maintenance of machines is 6, the expense charge would primarily be 1UX6. Should this expense, however, have been incurred directly by a machine in this department (say a boring machine No. 11, symbol of which is B11), the charge would be reported as 1UX6B11. In this way the charge is brought directly to the department and machine which actually incurred the expense. Grinding and maintainance of small miscellaneous tools are not directly chargeable to any particular tool. Such jobs are a toolroom expense and the charge would be 3UX9.

Piece Symbols

98. Piece symbols have caused more argument than perhaps any other set of symbols in use in modern organization work. As stated above, the writer, after years of experience with various forms of symbols, prefers the arbitrary number system to all others. A plain number, however, without letters is not sufficient for two chief reasons: first, that the plain number which is not accompanied by a letter is liable to conflict with other numbers; the second, that changes or modifications of a piece must be indicated in such a way as to be absolutely apparent at a glance.

99. All pieces should be symbolized without regard to whether they are to be made or purchased. All pieces are to have the same kind of symbols, consisting of a letter, numeral and the letter X (even though special and never to be used more than once). The reason for starting the symbol with the characteristic letter will be explained later under Drawing Symbols. All commercial articles, such as standard bolts, screws, nuts, taper pins, keys, wrenches, oil cups, washers, etc. should be symbolized, first commencing at 1X after the character letter. This should be systematically done and a symbol

provided for each kind and size of each article as listed in the maker's catalog, whether the article happens to be in demand at the time or not; it may be used later.

100. The parts made by the firm should next be symbolized, taking for the first piece the next unused number. This should also be systematically done by taking parts in the alphabetical order of their names and also in the order of their size. For example, if the first machine is "A Type," all A parts should be symbolized first; if the "A Types" consisted of say six sizes, the first sized piece (alphabetically) would be symbolized first and the other five sizes of this piece would take the next five consecutive numbers. After taking all pieces of all sizes in the "A Type" the next type (B for example) would be treated likewise and so on through all the different types and sizes. This explanation is made on the supposition that there are already existing machines and parts in use to be symbolized.

101. New parts should be symbolized in the order of their coming into use, and arbitrarily. It is easier in fact to be methodical in the arrangement of symbols than to go at it in a haphazard manner. A step in the right direction can be taken at the time the machine is being designed and while the material list is being created. The parts should be arranged systematically on the material list in groups and in the order in which they will be required by the shop, either by kinds of material or kinds of work, depending on the business involved.

102. It is a very good scheme in symbolizing new parts, to arrange them so that all iron castings, for instance, come together; after which may come bronze castings, steel castings, forgings, miscellaneous pieces, etc. Each new piece is symbolized by the use of the next unused number, but if one major piece requires one or two less important parts to make it complete, such as caps or brackets, these would naturally take the next following numbers in the order of their importance before symbolizing a new piece. It should be borne in mind that the foregoing is in no way essential to the scheme of symbols involved, but simply a small detail tending to a methodical way of doing a thing that is preferable to an unsystematic method.

XUM

103. Having provided for the piece and symbol proper, it becomes necessary to provide for alterations or changes to pieces which have been already symbolized. There are two chief changes to be provided for; one, that which is made to a pattern before a casting is made, and the other, which is simply a change in the dimension or shape, due solely to machining, where a standard casting is used. It is conceivable that a standard pattern of a wheel or gear, or some such common and regularly used piece, might be made slightly "special" a great many times by a slight alteration in the pattern. As there may be no limit to such possible changes, a numeral is added to the piece symbol after the suffix letter X. If a piece is to be made by an alteration to an existing pattern, say D1120X, a new piece made from this altered pattern would be known as D1120X1. The numeral after the X is to show that the pattern 21120X was altered, and indicates at once that a wholly new pattern is not required. The symbol of course, originates in the drafting room, as also does the design of the pieces. It is good practice to use existing patterns as far as possible, if the changes are not such as to permanently injure or weaken the pattern for use as originally intended. If this same pattern later had some other alteration or addition to make still another piece, the new piece would be known as D1120X2.

104. Where a change is one due entirely to a difference in machining a standard rough piece or casting, a letter is added to the end of the symbol after the suffix letter X, to indicate such a change in machining. A letter is used because it is not likely that the same piece would be machined in more than twenty-six different ways. Suppose, for example, we have a standard casting symbol D1120X, the only change required for a new piece being in the machining of it; the special piece would be symbolized D1120XA, the additional suffix letter A indicating a change only in the finishing. We know at a glance that the rough piece D1120X is the one to be used and the letter A indicates that it is the first machining change. To further illustrate this point, a blank bolt might be known as A621X. If threaded, say 3½ inches, it would then be A621XA; if

the same blank was used for a bolt faced under the head or otherwise different from above, it would be known as A621XB. As above stated, it is not likely that any one rough part would be machined in more than twenty-six different ways.

105. In the event that we have a standard pattern from which we are to make two special pieces by altering the pattern, making two castings alike, and then machining one slightly different from the other, one of these pieces would be known as D1120X2 and the other as D1120X2A.

106. This scheme, as worked out in practice, has repeatedly proved that there is a distinct advantage in having the above-described combination of numbers and letters as suffixes to the original piece-symbol suffix X. Of course, all piece symbols must be properly indexed in the piece-symbol index. This piece-symbol index is a double one on the card system—one set of cards being arranged numerically from 1X up. Though in general groups, they are arranged alphabetically according to the prefix or characteristic or letter. In a numerical index, if we are indexing piece D1120X, it will, of course, come in its proper position after D1119X. Should there be a modification of this piece, known as D1120X1, the card for this piece will follow the card D1120X. If there is still another card D1120XA, this would come in behind the last mentioned card. The following arrangement will show how the alphabetical index is arranged.

107. Arms

- A Type
  - 1 size
  - 2 "
  - 3 "
  - 4 "
  - 5 "
  - 6 "
- B Type
  - 1 size
  - 2 "
  - 3 "
  - 4 "
  - 5 "
  - 6 "
- C Type
  - 1 size
  - 2 "
  - 3 "
  - 4 "
  - 5 "
  - 6 "

108. There is a method of symbolizing pieces, known as the group scheme, which has also worked satisfactorily in practice to a limited extent. This scheme, however, has the same disadvantages as the mnemonic symbol system, namely, that it is more or less restricted and cannot be universally applied to any kind of business. A group scheme with a characteristic letter or letters followed or preceded by a numeral, adapted to one kind of business will not fit another line.

109. The trouble in developing any but a purely arbitrary symbol system is that the tendency is to work toward the mnemonic feature by trying to make the symbol suggestive. This scheme is absolutely impracticable if carried to any great extent. The tendency is toward complication, and while the symbols may be shortened by this method perhaps by one character, this slight saving is of no consequence and it ceases to exist if there is any great variety of pieces. Most any simple piece symbol will soon reach five characters, not including the suffixes added to represent alterations or variations from standard, such as have been described.

Jig and Special Tool Symbols

110. All special tools, jigs, templets, etc. should be symbolized to indicate without chance of error the pieces or parts for which they were specially designed. The simplest way to do this is to take the piece symbol, such as D1120X, D1120X1 or D1120XA and add to this symbol a small letter. The principle involved will simply show that there are a certain number of operations required to finish the piece. These operations can be lettered including everything from the pattern to the last finishing or other operation.

111. Before proceeding further, the writer wishes to state that a drawing is a tool just as much as is a jig, templet or other special tool. This is also true of patterns, as a pattern is distinctly a tool, without which those parts made in the foundry could not ordinarily be produced. As explained under drawing symbols, one has a characteristic letter indicating in the first place a drawing which is followed by the piece symbol proper (although, of course, as explained above, the entire symbol is

used for both piece and drawing). Let it be supposed, for example, that the pattern is the tool for the second operation or piece, and if it is desirable, as it may be in some lines of business to use pattern symbols, the pattern could be known as D1120X1 though it is absolutely superfluous as far as patterns are concerned. It but adds an unnecessary complication and the piece symbol can be used just as well for the pattern as not. If one is referred to piece D1120X he has an identification for the drawing, for the pattern and for the piece—the one symbol applies to all and there is nothing simpler or more satisfactory in practice.

112. There are subsequent operations after the casting has been made, or the forming is ready for machining, which may require a number of special tools. It is absolutely essential that these tools be easily and accurately identified. Let us assume that there are four machining operations on piece D1120X, for which special tools or jigs have been made, and that these four operations are operations 7, 10, 11 and 16. These jigs or tools would be symbolized respectively, as D1120X7, D1120X10, D1120X11 and D1120X16. Each of the several pieces of which the above mentioned jigs or tools are made up should, of course, be stamped with the symbol. If it becomes desirable to identify the separate parts of the jigs, as in cases where a jig is distinctly a double one, e. g. a male and female plug gage, the separate pieces may be identified by the addition of a suffix letter; for example, in a two-part jig, as mentioned above, for piece D1120X (for the 11th operation), one part of the jig would be numbered D1120X11A and the other part D1120X11B.

Operation Symbols

113. The most desirable symbols for operations, using the operation in the broadest sense, are two-letter symbols, as suggestive as possible. These symbols are necessary for use on work orders and other shop documents to save writing several (and sometimes a dozen) words to express what is desired in the way of instructions. Some of the more common ones are given below. It will be noticed that in almost every instance the symbol is perfectly suggestive of the words it represents.

Owing to the limits of the alphabet it is not possible to have any definite rule for constructing a symbol of this kind.

114. Some symbols taking the place of two words are formed by taking the first letter of each word, as for example AP, which stands for "alter pattern." Another case is a symbol BO for "bore," the symbol in this case being the first two letters of the word and suggestive. Again, the symbol BX for "box" consisting of the first and last letter of the word, is suggestive. In some cases the symbol is phonetic, as in the case of XP for "experiment." An hour's study of this list will enable one to memorize practically every symbol represented. Of course, different lines of business require different operations, but the list given can be used as a guide, and modified or expanded to suit individual cases.

Operation Symbols

115.

AF —Alter Flask
AN —Anneal
AP —Alter Pattern
AS —Assemble
AV —Approve
BA —Balance
BH —Broach
BK —Bake
BM —Box Mill
CA —Cancel
CB —Counterbore
CC —Set Chills
CD —Checked
CE —Center
CG —Charge
CH —Case Harden
CK —Chuck
CL —Clean
CN —Condemn
CO —Cut Off
CP —Chip
CR —Crate
CS —Countersink
CT —Cut Teeth
CU —Core Up
CZ —Cut Sand
DE —Design
DF —Defective
DL —Drill
DM —Dismantle
DN —Done
DO —Dump Out
DP —Don't Proceed
TP —Tap
BN —Bend
BO —Bore
BP —Bump
BS —Burnishing
BT —Babbitt
BU —Bush
BV —Bevel
BX —Box
BZ —Braze
LB —Laboring
LC —List Complete
LD —Load
LO —Lay Out
LP —List Partial
LR —Leather
MC —Make Cores
MD —Mold
MF —Make Flask
MI —Miscellaneous
MM —Moved to Machine
MO —Moved
MP —Material Provided
MT —Melting
MX —Mix
NH —No Help
NP —Nickel Plate
NY —Notified
OG —Oil Groove
OH —Overhead
OK —O. K.
OR —Ordered
PA —Paint

DR —Delayed for Repairs
DS —Dress
DW —Draw
EB —Equipment Broken Down
FA —Face
FD —Foundry Delay
FH —Finish
FI —File
FL —Fill
FM —Forming
FO —Forge
FR —Fire
FS —Forming Seat
FT —Fit
FU —Fit Up
GR —Grind
GS —Grease
HC —Held up to check
HD —Harden
HL —Helping
HO —Held up by Office
IL —Instal
IN —Invoice
IS —In Stock
IT —Inspect
JG —Jig
KE —Key
KG —Knocking Off Gates
KL —Kooling (Cooling)
KN —Kounting (Counting)
KO —Knockout
KR —Koloring (Coloring)
KT —Kutting (Cut or Cutting)
SP —Spherical
SR —Straighten
SS —Set Screw
ST —Slit
SU —Set Up
SV —Shovel
SW —Sweep
TB —Tumble
TD —Take Down
TE —Temper
TF —Tend Furnace
TH —Thread
TM —Trim
TN —Turn
TO —Take Out
PB —Plant Break Down
PD —Processing Deferred
PE —Prepare Equipment
PH —Photograph
PK —Pack
PL —Plane
PN —Pattern (make)
PO —Polish
PP —Prick (or center) Punch
PR —Pour Out
PS —Purchase
PT —Pulling Pot
PU —Punch
RD —Rub Down
RE —Receive
RI —Riddle
RM —Ream
RN —Requisition
RO —Resume Operation
RP —Replace
RR —Repair
RT —Rivet
RU —Routed
SB —Sand Blast
SC —Scrape
SD —Solder
SE —Setting
SF —Sift
SH —Ship
SK —Shrink
SL —Slot
SN —Spin
SO —Sort
TR —Trace
TS —Temper Sand
TT —Test
UD —Unload
UR —Urge
WA —Waiting for Approval
WD —Wind
WG —Weigh
WI —Waiting for Information
WL —Weld
WM —Waiting for Material
WO —Watering
WR —Wrapping
WS —Wash
WT —Want
XP —Experiment

Drawing Symbols

116. In connection with special detail drawings with but one piece depicted on a sheet, the following scheme of drawing numbers, or symbols has been evolved. In ordinary shop practice, shop drawings generally show several or more pieces

on one sheet which are issued to the shops either in the form of pencil drawings or blue prints. This method, however, is obsolete and modern practice is gradually coming to the new method of making individual drawings, showing but one piece on a sheet. The advantages of this are many, but need not be taken up here. In each case every piece must be drawn and figured complete, with clearances and tolerances, so it makes little difference in the work required, whether several pieces are made on one sheet or on several individual sheets.

117. Bearing in mind the fact that one piece is shown on a sheet, and this piece properly symbolized, the following method has been devised for drawing symbols. The primary object is to obviate a double index, and to use the piece symbol for the drawing symbol with a characteristic letter to indicate the size of the drawing. It is necessary, of course, to use standard-size sheets, which for convenience may be lettered as follows:

A size, 6 x 9 in.
B size, 9 x 12 in.
C size, 12 x 18 in.
D size, 18 x 24 in.
E size, 24 x 26 in.

118. Obviously it would not be practical to file these various sizes of drawings in one or more drawers, mixing the different sizes of sheets.

119. Assume now that we have detail drawing, showing the required number of views of one piece which we know by its symbol as piece 1120X. If the piece is drawn on a D size sheet (18 x 24 in.) the sheet or drawing symbol would be D1120X.

120. Bear in mind now that the X in the symbol indicates a piece symbol, and that all piece-symbol numbers are followed by one or more letters, the first of which is always an X. When a drawing reference reads D1120X, it means the drawing for piece 1120X. On the other hand, knowing the piece symbol 1120X would not enable us to locate at once the drawing; the combination should, therefore, always be used.

121. Primarily all that is needed for the piece symbol is the 1120X (and for special alterations or changes the suffixes

consisting of a numeral or letter as previously explained). To combine the piece symbol and the drawing symbol, however, it becomes necessary to differentiate between the different sizes of sheets used in the drawing room. Hence use the prefix, or characteristic letter. Were it practical to make all detail drawings on the same size of sheet, the first letter would be unnecessary.

122. Drawing filing cases must of course be provided with drawers or compartments of the proper sizes to take each of the above mentioned sizes of sheets, namely, A, B, C, D, E, etc. By this arrangement all A size sheets (6 x 9 in.) will be together or in adjacent compartments and arranged numerically in order of the number following the characteristic letter. This same arrangement is carried on throughout for each size of drawing.

Filing Symbols

123. A comprehensive scheme of filing requires a rather complete system of symbols. The following outline is given as an illustration of a scheme of symbols used by the author for his own personal files. In the development of a filing system the characteristic letters of the symbol must suit the specific conditions for which it is devised, so the following is not offered as a standard key, because it would not be exactly duplicated for other lines of business.

124. The complete general index of 3 x 5-inch cards should include all data necessary to locate any matter whatsoever of which there is any record. This index will in most cases be on the double or triple cross index system, and in many cases matter will be indexed under as many suggestive "catch names" as possible to insure its easy location. Generally speaking, the alphabetical index will locate the record at once without cross reference.

125. The different matter is classified as below. The numerals are arbitrary and used consecutively, each new record being given the next progressive number after the last one used in the group or classification in which it belongs, as indicated by the first letter of the symbol.

126. The first letter of the symbol indicates the group for classification. The second letter indicates in which file the record will be found. In the case of a card file a numeral (indicating one dimension of the card, 3 for 3 x 5, 4 for 4 x 6, and 5 for 5 x 8) comes between the first and second letter of the symbol.

127.

Key to First Letter of the Symbol

A	Author (F. A. P.)
B	Buildings, etc., exclusive of equipment
C	Comments and criticisms
D	Data and statistics
E	Engineering society publications
F	Forms
G	Graphical records, charts, etc.
H	
I	Instructions
J	Jigs, tools, cutters, forming, bending and other implements, fixtures, etc.
K	Catalogs, advertising matter, etc.
L	Letters, proposals and contracts
M	Machinery, power plant equipment, data, records of, etc.
N	Notes, memoranda, minutes, etc.
O	Organization and management
P	Photographs, pictures, etc.
Q	Queries
R	Reports, recommendations, rehabilitations, data, etc.
S	Speed data and records, time studies, etc.
T	
U	Unclassified matter of all descriptions.
V	Government and state acts, laws, etc.
W	Wage systems, workers, unions, welfare, work, etc.
X	Experiments, results of original investigations, etc.
Y	Instruments, slide rules, etc.
Z	Symbols

128.

Key to Second Letter of the Symbol

A	Albums
B	Bookcase or book files, loose leaf binders, etc.
3C	Card File, 3 x 5 card
4C	Card File, 4 x 6 card
5C	Card File, 5 x 8 card
D	Drawers, case of
F	Folders, letter size, in vertical filing cabinet
K	Catalog filing case
S	Safe

129. Examples—The symbol BB120 indicates building data, etc. in a book case, serial number 120.

SF116 indicates a speed record in folder 116, in vertical filing cabinet.

RF12 indicates report, etc. in folder 12, filed in vertical filing cabinet.

RB20 indicates a report in book form, number 20 in book case.

LF26 is a letter, filed in a folder in correspondence file, serial number 26.

D3C40 is data on a 3 x 5 in. card, number 40.

130. The numeral is in all cases arbitrary, except that it is desirable to be as systematic as possible at the start when indexing. Future additions must take the next open number in the correct classification, which number will indicate the order in which matter was accumulated or filed. In the case of books be sure to have a clear index card so as to quickly locate the page number when indexing specific matter.

131. If looking for letters in the general index there will be found under L in the proper position a large tab card headed "Letters." Behind this will be inserted a complete set of alphabetical guide card for Letters Only. This brings all letters together in the index. Forms, under FOR, have a large tab card followed by a set of alphabetical guides; a form can thus be readily found by form name. All of one company's forms will be indexed on one or more cards and found under the firm name in the general index.

132. Date on similar subjects under the same classification, may be filed in different places, owing to the various forms in which the subjects may be. All of one classification, however, will be together in each different file and the method is unlimited in its scope and expansiveness.

133. It is evident that a bound book of reports could not occupy the same file as the original copy of a single report—of comparatively few pages—which would naturally go into a vertical file folder. Brief memoranda occupying but small space but in large variety should be written on cards and filed

in the general index. If put into other card filing cases they would be indexed in the general index which would refer by symbol to the correct file.

Manufacturing Numbers

134. For purposes of identification of various pieces manufactured, especially the large and important parts of a machine, each part will be given a manufacturing number, or symbol. This number will consist of the stock job or merchandise job number followed by a letter, as L-401A, or L-401G, or again M-2809V, etc. The final letter of the symbol will be different on each piece built on a certain job, but the job number is the same. It is apparent by inspection that parts with a manufacturing number L401A, L401B, etc., were built on the same stock job, viz., L401.

135. If a stock job L401 calls for twelve pieces, then the manufacturing numbers run from L401A to L401L, inclusive. The same method, of course, applies to any manufacturing done on merchandise job numbers, but this will be an exception, as it is desirable to manufacture only on stock jobs, which numbers are always preceded by the letter S, and are the only job numbers used for the manufacturing of one or more single pieces exactly alike.

136. The manufacturing numbers on frames will in all cases be stamped on the main casting at some predetermined space, instead of marking the piece promiscuously. Care must be taken when filing and rubbing down not to cover the manufacturing number. The space bearing the manufacturing number should be indicated by having a white circle painted around it for easy identification. It is desirable, however, that the final coat of paint with a little machine filler should thoroughly cover the number previous to shipping, so that there will be no possibility of the customer finding it and mistaking it for the shop number.

137. Other articles will be numbered likewise as the necessity presents itself, and in all cases, excepting on frames or columns, which bear the shop number, the manufacturing number must be plain and in a conspicuous place. The manu-

facturing number should be noted on the article as soon as it arrives at the works, or if in stock, as soon as it is withdrawn from stock and before any work is done.

Resume

138. It must be understood that the arrangement of numbers and letters as described throughout this article can be modified or changed to suit conditions. A different arrangement of these characters does not change the principle involved. The examples given are simply in way of illustration, but they follow very closely a system of symbols which has proved successful in practice.

139. Though to the layman a symbol scheme seems complex, it works out in practice very simply as taken up step by step. It has proved a great labor-saving device, especially in connection with modern methods of management. Below is given a brief resume of what has been described in the preceding sections. By bringing the different groups of symbols thus together a comparison can readily be made. It will be seen that there is no confliction between them, as each symbol is in itself characteristic and indicates clearly to which group it belongs. Though in effect arbitrary, they can be generally applied and are not limited to any special kind of business.

140.

1A to 1Z	Departments
X1, X2, X3, etc.	are expense symbols indicating subdivision departmental expenses
O26050a	General order number
C1160	Contract number
L1520	Stock job number
M3160	Miscellaneous job number
P590	Plant job number
F329	Factory job number
1UM11	Milling machine, number 11, located in machine shop (1U)
DZ164	A miscellaneous tool not a commercial article
1UX6B11	An expense charge (6) to boring machine 11 (B11) located in machine shop (1U)
E5601X	Piece Symbol
E5201X13A	Special tool or jig for piece E5201X
E5201X1	Special part made by altering pattern of E5201X
E5201XA	A special piece made by machining a standard casting E5201X special
BO	Operation symbol for bore

E1120	A drawing on a sheet 24 x 36 inches. Detail drawings of an individual piece, no matter what it may be, are symbolized the same as the piece symbol.
LF26	Letters in vertical filing folder 26
D3C40	Date filed on a 3 x 5 card No. 40
L401A	Manufacturing number of a stock part made on job L401

9—The Control of Methods and Labor Through Time Studies and Standard Sub-Operation Times

141. All of the above mentioned pre-requisites have their value as a part of the whole. The actual savings they effect are very great, but we come now to the most radical part of real scientific management, that part which helps us immensely in the development of all the branches of management that have been mentioned earlier in this article and that part which makes possible a larger production than is otherwise obtainable.

142. Fundamentally we must obtain a thorough knowledge of all factors in a condition to scientifically control it. To do this we must first carefully analyze each thing we have to do into all its elements. Having done this the next step is to take up each branch or element individually and one at a time. The chief element aside from material in foundry work is labor.

143. The control of methods and the necessary labor element are closely related. In one sense the method is distinct from the labor necessary to make that method effective. On the other hand we cannot dispense with the labor. Our method may contemplate the most complex and efficient mechanical appliance, leaving but little for the human element to do to realize great productiveness from it. Yet, to repeat, we are helpless without the human factor.

144. In the perfection of methods we bring to bear specially trained minds. The material and tools to be used are carefully determined. The proper combinations of help (if it is gang job) are agreed upon. So too are the sequence of operations and the time each shall take. All of these factors are determined by careful study combined with the use of the stop watch.

145. To best describe the author's method of making time studies he gives below a modified copy of a set of instructions

covering the duties of a time study foreman. This instruction applies to a man in charge of time study work in one of the large foundries in which the author is installing his methods of scientific management. A large amount of detail applying to that particular business has been omitted for obvious reasons. The author hopes that the following will impress the reader with the great importance of this part of the work. Time study work well done is the key to the success of the entire scheme. If improperly or incorrectly carried out it is bound to plunge the entire scheme of organization into chaos. The final outcome can be readily foreseen.

10—The Time Study Foreman

146. The Time Study Foreman is a member of the planning room force. He is a functional foreman and is directly under the Production Clerk. Until the new methods are thoroughly operative, however, the Time Study Foreman will be directly under the Organizing Engineer and will be responsible to him only.

147. These instructions cover the duties of the Time Study Foreman and his one assistant. They are of course equally applicable in the event that there are more than two men employed on this work. The time study men are immediately responsible to the Time Study Foreman, who will be held strictly responsible for all branches of their work. This also applies to men detailed temporarily from other plants for instruction in time study work.

148. Too much stress cannot be laid on the importance of the work covered by these instructions. This applies both to the relative importance of this branch of the work to the entire organization as well as to the fact that it is the most important single element of the whole. The success of the entire bonus system is dependent on the reliability of the work of the Time Study Foreman and his assistants, and in the accuracy of their investigations and records.

149. The observer or time study man should be a skilled man of the trade under investigation. It is not absolutely necessary that he be the fastest worker in the shop, but he

must be one of the best. Pride and enthusiasm in his work are two of the chief essentials. To these may be added sound judgment and an unbiased mind, and above all things, he must be patient, exacting and extremely diplomatic. Many opportunities will arise for carrying tales. Care must be taken in conversation with the men that nothing is said which can be misconstrued. These things make trouble and must be absolutely avoided. A man who cannot observe these regulations will not be allowed to have anything to do with time study or bonus work.

150. The time study men must study the man as well as the job. They must win and retain the confidence of those with whom they come in contact. The time study men are functional foremen in every sense of the word. As such they come in contact sooner or later and more or less often, with every workman in the shop.

151. The observer when making a time study, should be sure to fill in all the information required at the top of the time study form, as indicated by the printed matter. The Substance of the "note" at the top of this form should *always* be borne in mind. Each job must be carefully and thoroughly analyzed into its various elements. The best sequence of operations, as well as the proper tools, feeds, speeds and cuts (if a machine job) must be determined before the study is completed. This is a most important record and must always be complete in itself for later reference.

152. First of all there are a great many standard elemental times to be determined and tabulated for us in connection with time studies and instruction cards. These elements occur repeatedly on all work of whatever nature which may be done in the different types of machine or by hand. Once determined, they represent a standard to be used in the future for that particular machine or group of like machines or other equipment. In addition to the above, full data must be tabulated covering all details of capacity, power, adaptability, etc., of each machine, maximum feeds, cuts, speeds, etc. Other elemental times are also necessary to the expediting and standardizing of this work. For example, standard time

allowances for setting different kinds of work in different types of machines, different sizes and styles of clamps and bolts, time needed to raise different weights from floor to machine, both by hand for small parts, and by crane or hoist for larger ones. Different trades, of course, all have different elemental operations.

153. All of these elemental times represent a much larger proportion of a man's daily work than any one would at first imagine. Although the class of work being done in a shop may vary greatly, both in sizes and shapes, a great deal of a man's time is consumed daily in doing the same thing over and over again. This statement applies to getting tools, starting and stopping his machine, setting and unsetting tools making adjustments performing hand operations, etc. Until an actual record has been made of the time so consumed, and this record compared with the time the same operations should take as proved by stop-watch observations, no one will be convinced of the true state of affairs. The analysis of new work into its elements then becomes a mere matter of applying standard elementary times to most of the elements and calculating or observing the times for the remaining few.

154. Before starting to make a time study, the right workman must be chosen for the job. He must be a fast and conscientious worker and skilled at the kind of work, or branch of the trade, under investigation. If such a man is not available, and a "green" man is to be broken in, the observer must demonstrate the various elements as the study progresses. First of all (other conditions being propitious), the man chosen to do the job must be one who is strictly loyal and thoroughly in sympathy with the new methods. Having chosen such a man, it is generally good practice to pay him 25 per cent of his hourly rate as a bonus for following instructions and while working under the watch. This payment should only apply as long as he continues to conscientiously do the best he can to assist toward an accurate and fair time study of the job in question. After a number of different men have become accustomed to working under

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the watch, this 25 per cent bonus should be regularly paid to each man when working under these conditions.

155. It will be somewhat difficult at first to win the operator's good will and hearty co-operation. When it is made clear to him that there are many elements in the job which can be improved, such as a different way of rigging up the job in the first place, or certain combinations of speeds, feeds and cuts, and that he has a chance of earning from 20 per cent to 40 per cent more wages under the new scheme, you have then brought home to him wherein he is to benefit. His work will at once become more interesting; hence, he can do much more work with less fatigue. A man's mental condition and environment are two factors which exert a most far-reaching influence on his output. His own and the employer's interest both require that these two factors be given careful consideration. Under these conditions each man is enabled to stand on his own feet. He is assured of the remuneration that is commensurate with his ability. He will not be wholly subject then to a prevailing rate of wages, which in so many cases is most unjust to both employe and employer.

156. Having chosen the man, the job must be studied and analyzed. This may require much experimenting by trying out one method after another. The tools and fixtures to be used must also be determined and listed so that for future repeat orders the proper tools may be made ready in the tool room and moved to the machine. This should be done in advance of the time the job is scheduled to start. The material must also be on the floor or at the machine or job.

157. In making a time study, every distinct sub-operation must be timed separately. All time is expressed in minutes and decimals on the time study form (see Fig. 6) after which the time is transposed into hours and decimals and figured to the nominal production per nine-hour day. Operation times that are too short to be accurately timed individually may be calculated. This may be done by taking the time for say four sub-operations, then by deducting the time taken for three to get the time for one. As the study progresses, all

unnecessary time should be noted and deducted. This includes time lost due to a man's too slow movements, waiting for or

TIME STUDY Form FAF 111 **THE ALUMINUM CASTINGS CO.**

TIME STUDY NO. ..... SHEETS, SHEET .....

ARTICLE ..... PIECE SYMBOL .....

SKETCH OR DRAWING ..... QUANTITY ..... OPERATION .....

MAN NO. ..... MACH. NO. ..... DEPT. ..... WORK, JOB OR ORDER NO. .....

TIME ..... A.M. P.M.

MATERIAL ..... OBSERVER ..... DATE ..... 19 ....

NOTE—The observer must exercise extreme care in making time studies to see that the proper sequence of operations is maintained, that all unnecessary operations or moves are eliminated, that proper appliances are provided and if machine work see that the proper and most economical combinations of Speed, Feed and Cut are used. When time is slow, due to man's natural slow moves, note (in margin at extreme right below) what time should be for a fast man moving at his best normal speed. Have certain operations repeated if necessary to satisfy yourself that the time is correct and continue to do so until the study is satisfactory.

Sub-Operation	DETAIL DESCRIPTION OF OPERATIONS SPEED, CUTS, ETC	MINUTES AND HUNDREDTHS 1	2	3	AVERAGE	ENDUED TIME
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
	TOTALS (OR CARRIED FORWARD)					

FINISHED ..... A.M. P.M. ELAPSED TIME FOR ..... — ..... MIN

FIG. 6—TIME STUDY FORM
Paragraph 157

preparing tools, as well as delays from any other source not necessary to the proper performance of the work.

158. After the work is under way, several time studies from different pieces of the same lot (if there are more than one) should be made on the one form. Three columns are provided for this purpose. In addition the column to the right is to be filled in showing the time that is finally decided on for each sub-operation. Eventually all elemental times will be standard and the times shown for them on the time study form will be ignored except to account for much waste time. Ten or twelve sheets are often required for one piece, or job, if it be a large or intricate one. The time study when completed will show all the detail times, equal in amount to the total elapsed time. It must be borne in mind that each study is based on a certain design of piece, made of a certain material, using specified equipment and tools, and is not to apply if one or more conditions are changed. The man, however, is the variable factor.

159. The kind and quality of material has also to be taken into consideration. Lack of material or faulty equipment will often prevent a man from earning bonus. The difference in quality of the material is beyond the control of the man, and if it prevents his earning a bonus, the management must expect to make an adjustment. No allowance, however, is to be made for delays in manipulation of the machine, work or tools. A shut-down of the machine for adjustment, cleaning, or minor repairs, will not be allowed unless it is shown beyond question that these delays were in no way due to the operator. In some cases, however, the job may be stopped, due to any of the above mentioned delays, and the operator put on other work. When the job is finally resumed, the total time elapsed while it was being worked on is used in determining the time per piece. It is up to the functional foreman to see that the machine and equipment are in proper shape *before* work is started on any job.

160. It must not be assumed that it is always an easy matter to get a sufficiently accurate time study, and hence a good set of instructions. In point of fact, time studies sometimes have to be made at different times from several successive lots or jobs before a satisfactory instruction card can

be issued or a bonus rate set. The time study man must often spend several consecutive days on one job, before he can get a satisfactory study. When this has been obtained, however, it is a comparatively easy matter to write up the instruction cards. These instructions, when written, form the permanent standard for that operation, until a change in one or more of its conditions necessitates a new one. The record in itself looks simple, but the preliminary work involved can be only appreciated by one who has been actively engaged in this kind of work.

161. The reader must not be misled in thinking that after a satisfactory time study has been taken and the instruction card made out, there is nothing more to be done. As often as not, this point marks the beginning of a more or less lengthy period of patient and systematic coaching. In the first place, several different men will probably work on as many successive lots. Until these men have been thoroughly accustomed to bonus work, they will not perform the operation as fast as they can eventually. This is true also of machine operators who perhaps run the same machine from one end of the year to the other, but on many kinds of work. Most men are more adept at one class of work than they are at another, even though it is performed on the same machine. Again, their mental attitude must be considered. They think that although they can earn ten or twelve cents an hour bonus on one job, they can make nothing on some new job. All these conditions and differences of opinion must be met and the employe instructed until he becomes proficient on each job put to him under bonus. This method also results in placing men at the work they are best fitted for. They cannot continue to work indifferently for perhaps years when they should have been on other jobs or working at some other trade. The writer has in mind a number of jobs which took from six to fourteen months of unremitting, patient labor on his part before a cent of bonus was earned on them.

162. If one or more men do not begin to immediately earn bonus after a bonus price has been set, the circumstances must be taken into consideration. They must be given an

opportunity to appreciate the fact that the job contains elements which they were before unfamiliar with. Make them realize that they have been shown how they can do the work quickly if they are so inclined. I quote an example which came up in our core room the other day, which is a particularly good illustration of this point. I refer to a half housing core, core box 3, for a transmission, bonus chart No. 53. This job had been run under day work from 75 to 85 cores a day and in the judgment of the foreman 90 cores could be made in nine hours. A time study on this job was made personally by the writer and afterwards a more systematic study was made by the Time Study Foreman. The result was that the job figured .83 minutes per core. Making an allowance of about 10 per cent, the maximum bonus production was figured on a basis of 0.9 minutes per core. This means a production of 600 cores per day for one man at the bench. Bonus was started at 70 per cent of this production (420) and the chart above referred to was issued on this basis.

163. It is a pretty radical proposition to take a "75 to 90 a day" job based on the best judgment of the man in charge of that department and attempt to jump it to 420 before the man can earn any extra remuneration. The man who had been working on this job refused to work under bonus and walked out. A strange man was put on the job and for the first day's work made 460 cores. On the second day he made 537. The foreman in this department then admitted that he believed a man could make 600 of these cores in nine hours. The job after a few days ran from 550 to 600 per day. This example is recorded here as a good illustration of the apparent radicalism of some of the results desired under new methods.

164. Be perfectly sure of your facts, then instruct and assist the men in every way in realizing the results you aim for. Keep an accurate record of the time you consume while making each time study and if the men are cooperating with you and trying in every way to assist you in making this study, see that a bonus pay slip is turned in for an amount equal to 25 per cent of their wages for the time they were

working under the stop watch. Be perfectly open and frank with them while taking time studies and do not get the habit of letting them think you are taking time studies secretly. I am not referring now to making the general superficial study of the job and taking the elapsed time, keeping the watch in the pocket. This method is allowable under certain circumstances as long as it is done discreetly and just as a rough check on conditions. There are only a few cases where such a method is necessary and the writer knows of none where it is desirable.

165. When taking time studies or arranging the order of work and teaching the men how to perform such work, be sure to make them realize the advantage of working at a steady gait. Do not let the men continue the habit which a great majority of them have; i. e. trying to put up a large proportion of the day's work during the morning period. We have been able to get our men away from this habit and it will be noticed that on practically every bonus job now running an average gait is maintained throughout the day. If the jobs were checked over at noon, you would find that almost invariably there is 5-9 of a day's work completed at 11:30. Such a condition is a most desirable one; the men can do more work with less fatigue than in any other way. For general information, it may be mentioned here that there is a certain limit to which a man can go before becoming unduly fatigued. If a very short rest period is taken at this time, a matter of only a few moments even, it will recuperate a man so that he can resume at his maximum speed. Let him work a little longer, however, at his maximum speed and it will not require a proportionately increased period of rest to recuperate, but the period will have to be many times longer. *A slower average gait steadily maintained* as above stated requires a great deal less effort for a greater production.

166. As each job is taken up and investigated preparatory to making a time study, be sure to get an accurate record of how the job is run, the number of men, and their rates. Also get an accurate record of the production per day both in gross work and net amount of good castings, cores, or whatever unit

applies to the job. This information is very essential for comparative purposes as well as to check out your cost after you determine the new way of arranging the job combined with the anticipated production. Very often it is necessary to change a method and at other times it is a very undesirable thing to do.

167. After you plan the arrangement of a job on the floor or bench, be sure to see that you provide a sufficient quantity of material. No matter how willing the men they cannot work to advantage (nor can you get a satisfactory study) if the flow of material is not sufficient to keep the gang well supplied and far enough ahead so that they do not see the possibility of a tie-up. You must not forget that the average workman is very clever at gaging his speed to suit conditions. Do not under any circumstances think that the men you are dealing with are fools, especially if they are of a different nationality and do not understand English. You will find that the minds of such men are peculiarly active. They are very quick to see an opportunity and take advantage of it. They are also exceedingly sensitive, far more so than the average better educated person.

168. Restrict each job, whether it is one man job or a gang job, to a certain but sufficient amount of floor, rack and bench space. Be careful to make your arrangement of work such that the different material and equipment is handy and can be reached and manipulated without an undue amount of travel or useless motions; on the other hand, allow sufficient room to work to advantage.

169. It is a mistake (except perhaps in isolated cases) to work more than two to six men and boys in a gang on bonus. The individuality of each man is lost and no one in the gang can work to the best advantage for several reasons; chiefly because men vary in capacity. When in too large a gang all are not congenial, are apt to be more or less jealous and antagonistic, or feel that each one is not doing his share and hence holding the others back. Work which can be done by a large gang must be so divided into sections that each section can be handled as a unit by one or two men. The result is the equivalent of a number of small individual units or jobs

which at a certain stage of completion, are themselves assembled in a short time, and perhaps by a number of men, into the completed work. In a case of this kind each unit or section is inspected separately as its assembling progresses. The final inspection takes place after the work is complete.

170. In the capacity of a time study man be careful to avoid any suggestion of usurping the authority of the foremen or gang bosses. They fully understand the relation of your work to their own; at the same time when you are ordered to take a time study of a job, arrange with the foreman and let him formally turn the men over to you. Very often the foreman will have good reasons for wanting to postpone the starting of such an investigation. These reasons may be due to promises that he has made in regard to his work, or to the fact that there is some change in equipment being made, etc. Such factors should be considered, but in every case report back to your superior. He may have more important reasons for wanting the study to start at once than those which have been given you for delaying it. Where you have occasion to criticize or suggest improvements in methods generally on jobs which you are not personally handling, take such matters up with the foreman or other proper authority. Do not give men instructions unless it is on a job which has been standardized. In such cases it is up to the Time Study Foreman and his assistants to maintain these jobs in their standard condition.

11—Time Study Instructions in Detail

171. All observations in the form of time studies, either rough superficial investigations or detailed stop watch observations are to be recorded on the time study form (see Fig. 6). These forms are to be numbered in consecutive numerical order, commencing at 1. Particular care must be exercised when starting a study on any piece of work to be sure that all of the information called for by the printed matter at the top of this form is filled in. When more than one sheet is used in recording the time study, these sheets must be numbered and the total number of sheets and "sheet number" (— Sheets, sheet —) filled in on *each* sheet belonging to a set of time studies.

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172. As a general word regarding time studies, the note printed near the top of the time study form should have particular attention, namely—

173.

"The observer must exercise extreme care in making time studies to see that the *proper* sequence of operations is maintained, that all *unnecessary* operations or moves are eliminated, that proper appliances are provided and if machine work, see that the proper and most economical combinations of Speed, Feed and Cut are used. When time is slow, due to man's natural slow moves, note (in margin at extreme right below) what the time should be for a fast man moving at his best normal speed. Have certain operations repeated if necessary to satisfy yourself that the time is correct and continue to do so until the study is satisfactory."

174. The note is printed on the form so that it may always be a continual brief reminder of the several very important elements to be considered in connection with time study work. These are elaborated on in considerable detail below but too much emphasis cannot be laid on their importance. Each time study or observation, whether one of a series of studies of standard elemental sub-operations, or a time study of some specific operation or job, should always be conducted in a systematic and routine manner and in strict accordance with the following:—

175.

a—Take nothing for granted, get all the *facts* and do not jump at conclusions; let these facts lead you to a conclusion and you will seldom go wrong.

176.

b—Prepare the heading on the time study form above referred to, filling in *all* the data called for.

177.

c—Use a decimal stop watch and express all time in minutes or hundredths of a minute (see Fig. 7). For each sub-operation (note explanation in (d) make at least 3 observations. The first of these observations should not be made until the job is rigged up and arranged in the manner in which it is to finally run, until the men have become thoroughly familiar with what is to be done, and until they have obtained a maximum amount of dexterity in the manipulation of the work or tools. The second and third observations should not necessarily follow consecutively after the first. Sometimes it will be of advantage to do this and at other times, it will be better to make the second and third observations at intervals of perhaps several days. The conditions of the job and its nature, as well as other influencing factors will settle this point.

178.

The "average time" (for which a column is provided) is a matter of calculation and can be done after the study is complete. Very often, however, it will be necessary to fill in the time the job should take (for which the extreme right hand column is provided) at the time the three observations are being made. Conditions govern this, but there will be occasions when there is a definite loss of time on a sub-operation due to certain hindrances which can be corrected at the time the observations are being made. If the correct time is not noted immediately, it may be overlooked.

179.

d—Reference has been made above to "sub-operation;" it will be noted that on the second line of the heading of the time study form, the third item is "operation." (See Fig. 6). Operation as here used means the general operation or job under observation. This general operation may consist of a great many sub-operations, some of them being purely elemental and continuously repeated, no matter what the particular job is that is being worked on. Other sub-operations are special to a particular operation or job. This explanation is put in here so that the words "operations" and "sub-operations" will not be confused.

180.

To further explain—suppose we are taking a time study on a molding operation, say for a simple floor job conducted by one man. The entire work of making this mold is an operation. Placing the bottom board, setting the pattern, dusting on parting sand, setting sprues and risers, setting flasks, shifting the first layer of sand, setting nails and gaggers, shoveling sand, ramming, striking off, etc., are all "sub-operations" of a "molding operation." A similar explanation is applicable to coremaking, knockout, trimming, soldering, etc., all of which are "operations." *Note*—See paragraph (g).

181.

e—The next step is to see that the equipment which has been provided for the operation is operative and arranged to the best advantage on the floor, bench or other place provided. It is essential that no more floor space be devoted to a job than is necessary for the maximum amount of work; on the other hand, it is equally inefficient, often more so, to provide too little space. In work calling for the co-operation of two or more men, their respective "sub" or "part" (see g) based on the time they take, operations should be so arranged that the men can work in unison and with the minimum of delay. Be sure that the tools are in first class condition and in sufficient quantities, and that the man knows how to handle them. (See m).

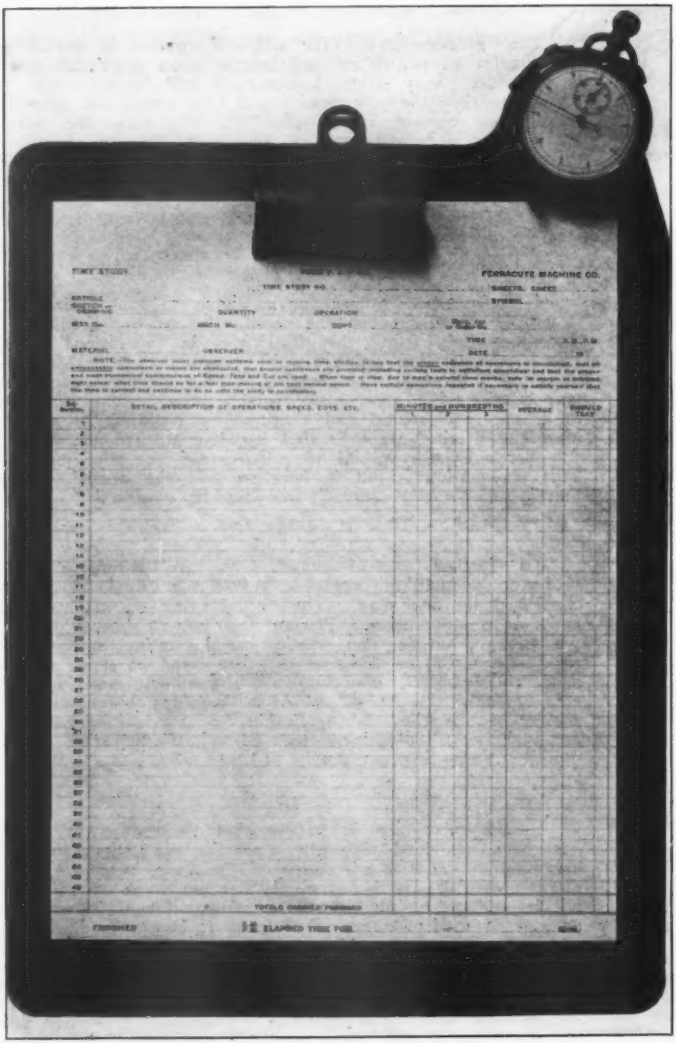

FIG. 7—TIME STUDY OBSERVATION-BOARD, WATCH AND FORM
Paragraph 177

182.

If the best arrangements cannot be determined beforehand, make experiments enough to determine this point beyond question before proceeding further. In such cases, see that your time study form shows an explanation of what this arrangement should be. This may be written in the body of the form in the column headed "detail description of operations, speed, cuts, etc."

183.

f—Having arranged the above-mentioned preliminaries, the next thing is to carefully study the personnel of the employes. A careful study of this phase of the problem will show that a great many men misplaced and are doing either the wrong kind of work, or are not fitted for the particular part of the kind of work they are doing. This is particularly noticeable where gang work is involved. Very often the men doing the hard physical labor requiring little or no skill are the men physically less fitted for the kind of work. We likewise too often find as a result of precedent, a skilled molder employed as a gang boss on a molding floor setting cores on a class or work for which only a bright, though inexperienced man is necessary. "Misfits" such as these are innumerable, except in the most highly developed organizations.

184.

The personal factor is the one great element to be watched, studied, "placed" and controlled before permanent improvement in methods is possible. All these conditions should be taken into consideration as first stated, and the gangs rearranged to suit the job on which they are to be employed. Such changes should be taken up through the planning room and the department foreman. It is fully appreciated that we cannot always make up gangs to suit every individual job. We can, however, regulate our work more or less by classes and divide our gangs into similar classes. Keep each class of workmen as much as possible on the class of work for which they are best fitted.

185.

g—The next step is to study the details of the job and in a general way separate it into several parts. For example—if it is a "gang" molding job, the work on the cope would be considered one general part of the operation and the work on the drag would be considered another general part of the operation. Other "part operations" would be finishing, core setting, green sand coremaking, closing and clamping molds, setting pouring cups and cups and dumping out. Study each part of the work as though it were a complete "operation" then sub-divide it into its sub-operations. In doing this be sure that all unnecessary moves or sub-operations are eliminated. Where more than one man is working on a sub-operation or part operation, see that their respective sub-operations are so timed that they are being done together. In other words, if three men are working on a cope each of them

should have something to do all the time that the cope is in their hands; one or two should not be obliged to stand and wait while the one finishes his delayed sub-operation. I have timed many jobs where only two men were involved, and found that they have taken more than twice as long as they should for the reason that the above-mentioned points were utterly ignored.

186.

Before taking up the next step, be sure that the division of the job into its several parts just mentioned, is complete and logical and that you are thoroughly familiar with each sub-operation or each part of an operation. Take nothing for granted and see and understand for yourself exactly why, when and how every sub-operation is performed. Then, and only then, can you *know* how to proceed or feel you are on the right track.

187.

h—Take each part of the operation and list on the time study form in the logical and practicable sequence its various sub-operations. Also clearly state under each part the number of men involved and where a sub-operation is done by two or more men be sure to note beside it the number of men. In timing sub-operations be sure to see that an entire combination going to make up the particular operation are working smoothly and that the rough elapsed time is fairly even. Having done this, each sub-operation can be timed independent of all other considerations. Do not lose sight of the fact that the decimal stop watch is arranged to stop and start, accumulating time of each successive operation and need not be thrown back to zero until the sub-operation is completed. If you have started the time on a sub-operation and something interferes with the continuation of it, or causes a delay, stop the watch until the job is resumed at this point and at a normal speed. To illustrate—you may hold the watch on a sub-operation for twenty minutes total elapsed time, but if you follow the above instructions, the watch will sometimes show only perhaps five or six minutes (or less) as the actual required time for that sub-operation.

188.

The manipulation of the watch on the above basis (and judgment of what time to eliminate) is one of the chief essentials when taking time studies. If a time study man cannot master this part of the work and always be sure of the correctness of his time studies, he cannot hold his position. You will find that the average workman often unintentionally combines a great many useless operations. This condition will be found most often where you have laid out a method of operation different from that to which he has been accustomed. Under such circumstances you must expect him to make mistakes and do things in their improper order or do unnecessary things. These should be eliminated. In other words, if the above instructions have been followed out, you have determined a definite method and sequence of operations and *you are only*

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expected to take the time of these necessary operations. These are the times which are to appear in the columns marked "1", "2" and "3" on the time study form, figures 6 and 7.

189.

Do not lose sight of the fact that under the new methods each employe has fewer things to do than formerly. Do not allow time taken in getting material to him or his work away from him. Preparation and care of tools (dressing, grinding, repairing, etc.) are not up to him; neither is inspection, looking up and preparing his next job, keeping time and similar work formerly saddled on the workman. In the foundries, dumping out, pouring off, laboring, etc., are all specialized where formerly these things were done more or less by everyone.

190.

i—In making time studies or observations on other than standard elemental operations, it is not necessary to take the time of any standard elemental sub-operation involved on that particular job. As explained below, all the standard elemental operations will be charted and standard times determined for them. These standard elemental operations will be numbered numerically. Where they form sub-operations as explained above, they may simply be referred to on the time study form by number. When you come to figure up the right hand column to show the time the job should take, the standard elemental time should be taken from the standard elemental time sheets. You will find that eventually the actual time study work involved will be very small, and then only for exceptional work. The time for the majority of operations can be taken from the standard elemental time sheets.

191.

j—Under no circumstances base a time study on the speed of an unusually fast man; the same thing applies to the unusually slow man, as in either case the result of your time study would be of no value. It must be clearly borne in mind that what we want is the correct time that the job should take when done by the average fast, industrious workman of the type and qualifications necessary for that particular kind of work. Do not be afraid to take averages and the more time you take as a check the better. Furthermore, bear in mind that what time you are taking is to be used as a basis for issuing bonus charts, the prices on which are under no circumstances to be lowered as long as the job remains the same or is done by the same tools, equipment, methods, etc., as were in use when the bonus chart was figured. *It is one of the fundamental principles of my methods of Scientific Management that the facts be correctly determined in the first place and that a schedule in prices or bonus chart is to remain unaltered.* The success of the entire scheme hinges upon this one thing. You must solicit the co-operation of the men, and win and hold their confidence. Super-judgment is necessary; be sure you are right and take time enough to do your work well.

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192.

k—Having completed the time study with at least three sets of final observations, the average time should be figured out for each sub-operation and filled in on the sheet. Sub-operation times should be totalled for each part of the general operation and these "part operations" compared. Then fill in the time that the work should take, doing this by part operations so that the various part operation times may be compared. This really is the time that you have got to work on. Where it is shown that one part of an operation takes longer than another part and that these parts must be completed in substantially the same time, it is obvious that something must be done to balance up the time on the slow part. You know that theoretically the fast operation represents the best normal production for the job. An extra man must be put on the slow operation or some other change made to balance it up with the fast one. When making such a change, it is well to make an additional time study as a check on your figures before issuing instruction cards or bonus charts to the workmen.

193.

l—On some jobs, operations, or particular classes of work there will be a number of sub-operations which are incident only to the entire job as a whole. For example—when a new job is started there may be instructions to explain, there may be drawings to become familiar with, there may be certain arrangement of the work on the floor, or in the machine which, having once been done, apply to the entire quantity or until the job is completed. Such elements in some cases may be standard elemental operations or they may be special to that job. In any event they are what we call *lot operations* and the times for them are known as *lot times.* In cases where these lot operations are repeated daily, a proportion of their total should be allotted to the operation under investigation based on, we will say, one day's work. A day's work constitutes a certain given production. The lot time distributable to a day's work should be divided by this number of pieces based on the time study and an item included on the time study to represent the lot time.

194.

Where lot times are such that they are not repeated, or cannot be proportioned to any definite amount of product as may be the case where a new job is started, and is being rigged up, this time may be or may not be included in the individual piece operation time. In such cases it will be assumed that this lot time has been spent once and for all, no matter how long the job runs. In such a case, consider it a "part operation" and get your study of it for further reference. Likewise, where there may be certain lot operation times at the completion of a job which has run a great many days or weeks, this may be considered as a factor not particularly affecting the operation times. This is so considered as far as time study work is

concerned (except as explained above) but of course such distributable lot time is all charged up to the cost of the job.

195.

m—In studying operations as above described, be sure that the necessary work at the beginning of the day or at the close of the day's work is included in your time study. Such work is essentially a lot operation, the time for which is "Lot Time" referred to above in paragraph (1). The care which tools should be given at night and the order in which the floor, bench, machine or job must be left should be clearly settled and the allowance of time for putting it in such condition provided. Such times are primarily daily lot times and are easily distributable pro rata to each operation performed for the day's work. In specifying the condition of equipment be sure that tools which are liable to rust are kept clean and well oiled and also see that the mechanical equipment provided is kept well oiled and adjusted, either by the operators themselves or by the maintenance department. Report all cases of abuse of tools. Do not let men use a shovel for an axe or as a crowbar.

12—Standard Elemental Sub-Operation Times For Floor Work

196. Reference has been made above to standard elemental operations; these are more correctly described as standard elemental sub-operation as they are really sub-operations, combinations of which form "operations." The method of procedure in taking standard elemental times is the same as described above in considerable detail and as there stated, this description applies to all types of time study work. It is essential that before much general time study work is undertaken, we determine these standard elemental times.

197. The following (see Table I) is given as representative of the more important standard elemental operations for foundry work. It will be noticed that the following table is divided into two classes. One class includes those times which are influenced almost solely by the size or weight of the flask used. The other class representing those operations which are more or less dependent on the kind of equipment or method in use. In the first class a different time will be realized for each sub-elemental operation for each flask in use. In the second class, the same is true for each sub-elemental operation

for each flask in use, except that there is the additional factor that the same combination may be used in any one of the five or six methods, namely:

198.

Bench Molding (Hand & Machine)
Floor Molding
Hand rollover machines
Power rollover machines
Stripping plate machines
Jar ramming machines
Other methods may come into future use

The above items are illustrative rather than specific.

TABLE I

STANDARD ELEMENTAL SUB-OPERATIONS FOR FLOOR MOLDING

Ref. No.	Sub-operation.	Flask T1	T2	T3	T4	Etc.
1	Brush off pattern	—				
2	Blow off pattern	—				
3	Dust on parting	—				
4	Set 10 lb. flask	—				
5	Set 20 lb. flask	—				
6	Set 30 lb. flask	—				
7	Set 40 lb. flask	—				
8	Set 80 lb. flask	—				
9	Set 60 lb. flask	—				
10	Set 70 lb. flask	—				
11	Set 80 lb. flask	—				
12	Set 90 lb. flask	—				
13	Set 100 lb. flask	—				
14	Set 120 lb. flask	—				
15	Set 140 lb. flask	—				
16	Set 160 lb. flask	—				
17	Set 180 lb. flask	—				
18	Set 200 lb. flask	—				
19	Set 220 lb. flask	—				
20	Set 1 sprue	—				
21	Set 2 sprue	—				
22	Set 3 sprue	—				
23	Set 4 sprue	—				
24	Set 1 riser	—				
25	Set 2 riser	—				
26	Set 3 riser	—				
27	Set 4 riser	—				
28	Set 5 riser	—				
29	Set 6 riser	—				
30	Set 7 riser	—				
31	Set 8 riser	—				
32	Set 9 riser	—				
33	Set 10 riser	—				
34	Set 11 riser	—				

35	Set 12 riser	—
36	Sift sand ¼-inch deep	—
37	Sift sand ½-inch deep	—
38	Sift sand on pattern 1 inch high	—
39	Sift sand on pattern 2 inches high	—
40	Sift sand on pattern 3 inches high	—
41	Sift sand on pattern 4 inches high	—
42	Sift sand on pattern 5 inches high	—
43	Sift sand on pattern 6 inches high	—
44	Sift sand on pattern 7 inches high	—
45	Sift sand on pattern 8 inches high	—
46	Sift sand on pattern 9 inches high	—
47	Sift sand on pattern 10 inches high	—
48	Sift sand on pattern 11 inches high	—
49	Sift sand on pattern 12 inches high	—
50	Press sand around pattern	—
51	Tuck straight bans	—
52	Tuck slant out bans	—
53	Tuck Vertical bans	—
54	Tuck irregular bans	—
55	Shovel in 4 inches sand	—
56	Shovel in 5 inches sand	—
57	Shovel in 6 inches sand	—
58	Shovel in 7 inches sand	—
59	Shovel in 8 inches sand	—
60	Shovel in 9 inches sand	—
61	Shovel in 10 inches sand	—
62	Shovel in 11 inches sand	—
63	Shovel in 12 inches sand	—
64	Shovel in 13 inches sand	—
65	Shovel in 14 inches sand	—
66	Shovel in 15 inches sand	—
67	Ram 4 inches sand "light"	—
68	Ram 4 inches sand "medium"	—
69	Ram 4 inches sand "hard"	—
70	Ram 6 inches sand "light"	—
71	Ram 6 inches sand "medium"	—
72	Ram 6 inches sand "hard"	—
73	Ram 8 inches sand "light"	—
74	Ram 8 inches sand "medium"	—
75	Ram 8 inches sand "hard"	—
76	Fill flask 3 inches above top	—
77	Fill flask 4 inches above top	—
78	Fill flask 5 inches above top	—
79	Fill flask 6 inches above top	—
80	Step off	—
81	Butt ram	—
82	Level off "shovel"	—
83	Level off "hard"	—
84	Strike off	—
85	Pull 1 sprue	—
86	Pull 2 sprue	—
87	Pull 3 sprue	—
88	Pull 4 sprue	—
89	Pull 1 riser	—
90	Pull 2 riser	—
91	Pull 3 riser	—

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92	Pull 4 riser	—
93	Pull 5 riser	—
94	Pull 6 riser	—
95	Pull 7 riser	—
96	Pull 8 riser	—
97	Pull 9 riser	—
98	Pull 10 riser	—
99	Pull 11 riser	—
100	Pull 12 riser	—
101	Level off before board goes on	—
102	Put on board	—
103	Rub board to good bearing	—
104	Clamp board with 2 clamps	—
105	Clamp board with 4 clamps	—
106	Clamp board with 6 clamps	—
107	Clamp board with 2 clamps and wedges	—
108	Clamp board with 4 clamps and wedges	—
109	Clamp board with 6 clamps and wedges	—
110	Clamp board with automatic clamp	—
111	Roll over by hand, 1 man	—
112	Roll over by hand, 2 men	—
113	Roll over by hand, 3 men	—
114	Roll over by hand, 4 men	—
115	Roll over by hand, 5 men	—
116	Roll over by hand, 6 men	—
117	Roll over by hand, 7 men	—
118	Roll over by hand, 8 men	—
119	Roll over by hand, 9 men	—
120	Roll over by hand, 10 men	—
121	Roll Tabor hand rollover machine, 1 man	—
122	Roll Tabor hand rollover machine, 2 men	—
123	Roll Tabor hand rollover machine, 3 men	—
124	Roll Tabor hand rollover machine, 4 men	—
125	Roll Pridmore rollover machine, 1 man	—
126	Roll Pridmore rollover machine, 2 men	—
127	Roll Pridmore rollover machine, 3 men	—
128	Roll Pridmore rollover machine, 4 men	—

		8-inch	12-inch
129	Rollover Tabor power rollover machine	—	
130	Rollover Pridmore power rollover mach.	—	
131	Wedge up under board	—	
132	Unclamp (See above item No. 107)	—	
133	Unclamp (See above item No. 108)	—	
134	Unclamp (See above item No. 109)	—	
135	Rap by hand	—	
136	Rap by vibrator	—	

		Hand Tabor	Hand Pridmore
137	Rap by hand and draw pat. on mach., 1 in.	—	
138	Rap by hand and draw pat. on mach., 2 in.	—	
139	Rap by hand and draw pat. on mach., 3 in.	—	
140	Rap by hand and draw pat. on mach., 4 in.	—	
141	Rap by hand and draw pat. on mach., 5 in.	—	
142	Rap by hand and draw pat. on mach., 6 in.	—	
143	Rap by hand and draw pat. on mach., 7 in.	—	

144	Rap by hand and draw pat. on mach., 8 in.	—
145	Rap by hand and draw pat. on mach., 9 in.	—
146	Rap by hand and draw pat. on mach., 10 in.	—
147	Rap by hand and draw pat. on mach., 11 in.	—
148	Rap by hand and draw pat. on mach., 12 in.	—

			By 5 lb. to 25 lb. By 10 lb. to 200 lb.		
			5 lb.	10 lb.	15 lb.
149	Draw pattern by hand, 1 in.	—			
150	Draw pattern by hand, 2 in.	—			
151	Draw pattern by hand, 3 in.	—			
152	Draw pattern by hand, 4 in.	—			
153	Draw pattern by hand, 5 in.	—			
154	Draw pattern by hand, 6 in.	—			
155	Draw pattern by hand, 7 in.	—			
156	Draw pattern by hand, 8 in.	—			
157	Draw pattern by hand, 9 in.	—			
158	Draw pattern by hand, 10 in.	—			
159	Draw pattern by hand, 11 in.	—			
160	Draw pattern by hand, 12 in.	—			

			Time for each.				
			Hand Tabor	Hand Pridmore	Power Tabor	Power Pridmore	Strp. Plate
161	Draw pattern on machine, 1 in.	—					
162	Draw pattern on machine, 2 in.	—					
163	Draw pattern on machine, 3 in.	—					
164	Draw pattern on machine, 4 in.	—					
165	Draw pattern on machine, 5 in.	—					
166	Draw pattern on machine, 6 in.	—					
167	Draw pattern on machine, 7 in.	—					
168	Draw pattern on machine, 8 in.	—					
169	Draw pattern on machine, 9 in.	—					
170	Draw pattern on machine, 10 in.	—					
171	Draw pattern on machine, 11 in.	—					
172	Draw pattern on machine, 12 in.	—					
173	Return machine to ramming position	—					

199. Everything depends on the accuracy of the sub-elemental operation times. Obviously unusual care must be made in the selection and arrangement of equipment, as well as in recording conditions. Likewise, the operative that is being timed must be of the right capacity, and qualifications, both physical and mental. In this connection, take the average times of at least five different men or groups of men of the qualifications above described in the earlier part of these instructions.

200. All of the standard elemental sub-operations listed below should be timed at least twenty different times for each different condition and with each of the five average may be made. In some cases it will be desirable and practicable to take a great many more than twenty observations (under each varying condition), especially on short sub-operations. Where reference is made to taking twenty observations, it does not mean a total of twenty where you are using five different men, but twenty observations for each of the five or more men. On this kind of work accuracy is everything, for times once determined for a given condition, cannot be changed. As previously stated, they constitute a large percentage of future time determinations.

13—Standard Sub-Elemental Times for Bench and Squeezer Work

201. In section 12 above will be found a long list of variables for floor work, on which standard times apply. A similar list of standard sub-elemental operations has also been worked up applicable to bench and squeezer work. There are about 31 of these elemental sub-operations for all of which standard times have been determined for various classes of work.

202. The variables to be provided for in establishing these standard times have been brought down to a definite standard. They consist of the following:—

203. Job Classes
1—Non cored work
2—Cored work

204. Pattern Equipment
Single
Gated
Plated

205. Methods
Bench (All hand methods)
Machine (Power and hand Squeezer)

206. Flasks

Snap and solid flasks—15 different sizes by plane dimensions and 5 depths for each:—75 combinations in all.

207. The following will help to describe more fully the subdivisions of the above job classes. It may be mentioned here that plated patterns come in the same "job class" as gated work. See Fig. 8, which illustrates a few of the many varieties of work which has been standardized.

208. Job Class 1 Non-Cored Work

1a. Plain—single pattern
1b. Plain—gated pattern
1c. Irregular—single pattern
1d. Irregular—gated pattern
1e. Complicated—single pattern
1f. Complicated—gated pattern

209. Job Class 2 Cored Work

2a. Plain—single pattern
2b. Plain—gated pattern
2c. Irregular—single pattern
2d. Irregular—gated pattern
2e. Complicated—single pattern
2f. Complicated—gated pattern

210. In addition to the standard times which apply to both cored and non-cored work must be added core setting times for job class 2 work. Times have been established for core setting covering from 1 to 8 cores for a single pattern and from 2 to 42 cores per mold for gated or plated patterns.

211. Based on the factors referred to in the last 3 preceding paragraphs, we have the following combinations for any of which it is possible to instantly determine the standard production data directly from the tables, viz.—

212.

Standard production all tabulated and indexed (as per Table 2)	36325.
Elemental operation times (bench)	900.
Elemental operation times (bench plated)	900.
Elemental operation times (machine)	900.
Elemental operation times (machine plated)	900.

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TABLE II

A TYPICAL STANDARD PRODUCTION DATA TABLE.

Size	Deep	Contents		JOB CLASS 2E BONUS CLASS 8 — Number of Cores to Set Single Pattern									
				1	2	3	4	5	6	7	8	2	4
10x24	6	1440	M	168	154	142	132	122	114	107	101	147	145
			P	168	154	142	132	122	114	107	101	294	580
			C	2585S	1723S	2032S	3020S	3252S	3229S	3243S	3245S	2330S	2163S
	7	1680	M	159	146	135	126	117	110	104	98	140	138
			P	159	146	135	126	117	110	104	98	280	552
			C	2586S	2731S	2288S	3234S	2691S	3241S	3246S	3246S	2331S	2526S
	8	1920	M	150	139	129	120	113	106	100	95	133	132
			P	150	139	129	120	113	106	100	95	266	528
			C	2031S	2730S	2530S	3224S	3228S	3239S	3253S	3259S	2332S	2541S
	9	2160	M	143	133	123	116	109	102	97	92	127	126
			P	143	133	123	116	109	102	97	92	254	504
			C	2534S	2033S	2531S	3236S	3238S	3255S	3261S	3257S	3004S	2540S
	10	2400	M	136	127	118	111	105	99	94	89	122	121
			P	136	127	118	111	105	99	94	89	244	484
			C	2529S	2034S	3230S	3232S	3242S	3256S	3258S	3287S	1701S	3159S
11x26	6	1716	M	158	146	135	125	117	110	103	98	138	136
			P	158	146	135	125	117	110	103	98	276	544
			C	2287S	2731S	2288S	3226S	2691S	3241S	3240S	3246S	2528S	2350S
	7	2002	M	148	138	128	119	112	105	99	94	131	129
			P	148	138	128	119	112	105	99	94	262	516
			C	2042S	3225S	3223S	3235S	3237S	3242S	3256S	3258S	2377S	2165S
	8	2288	M	140	130	121	114	107	101	95	91	124	123
			P	140	130	121	114	107	101	95	91	248	492
			C	2029S	2590S	3227S	3229S	3243S	3245S	3259S	3264S	2595S	2166S
	9	2574	M	132	124	115	108	102	97	92	87	118	117
			P	132	124	115	108	102	97	92	87	238	468
			C	3020S	2733S	3231S	3233S	3255S	3261S	3257S	3304S	2693S	1724S
	10	2860	M	125	118	110	104	98	93	88	84	112	111
			P	125	118	110	104	98	93	88	84	224	444
			C	3226S	3230S	3241S	3244S	3246S	3262S	3260S	3318S	1704S	1726S
12x16	6	1152	M	180	164	150	139	128	120	112	105	157	155
			P	180	164	150	139	128	120	112	105	314	620
			C	2036S	2038S	2031S	2730S	3223S	3224S	3237S	3242S	2096S	2928S
	7	1344	M	171	157	144	133	124	116	109	102	151	149
			P	171	157	144	133	124	116	109	102	302	596
			C	2037S	2039S	2283S	2033S	2733S	3236S	3238S	3255S	2593S	1767S
	8	1536	M	163	150	138	129	120	112	105	100	145	143
			P	163	150	138	129	120	112	105	100	290	572
			C	2027S	2031S	3225S	2530S	3224S	3237S	3242S	3253S	2167S	2226S
	9	1728	M	156	144	133	124	116	109	103	97	139	137
			P	156	144	133	124	116	109	103	97	278	548
			C	2692S	2283S	2033S	2733S	3236S	3238S	3240S	3261S	2537S	2164S
	10	1920	M	150	139	128	120	112	106	100	95	134	132
			P	150	139	128	120	112	106	100	95	268	528
			C	2031S	2730S	3223S	3224S	3237S	3239S	3253S	3259S	2596S	2541S

Elemental operation times (core setting)	69.
Standard times applying on the above and admitting of an almost unlimited combination	1440.
Operations variable by both job class and mold sizes...	900.
Total tabulated combinations	42334.

213. Though the above represents over 42,000 tabulated combinations, it is possible to make up other combinations to meet almost any desired case. It often happens that some

TABLE II—Continued
A TYPICAL STANDARD PRODUCTION DATA TABLE.

JOB CLASS 2F BONUS CLASS 8

Number of Patterns on Plate

6	8	10	12	14	16	18	20	22	24	30	36	42
143	**141**	**139**	**135**	**133**	**130**	**127**	**125**	**123**	**120**	**116**	**113**	**110**
858	1128	1390	1620	1862	2080	2286	2500	2706	2880	3480	4068	4620
2224S	1779S	2552S	2084S	2316S	1814S	3012S	2716S	2130S	1884S	2123S	2726S	1933S
136	**135**	**132**	**129**	**127**	**124**	**122**	**120**	**118**	**116**	**111**	**108**	**106**
816	1080	1320	1548	1778	1984	2196	2400	2596	2784	3330	3888	4452
1752S	1783S	2504S	2149S	3010S	2632S	2445S	2214S	3274S	2186S	3126S	1893S	3284S
130	**128**	**126**	**124**	**121**	**119**	**117**	**115**	**113**	**111**	**107**	**104**	**103**
780	1024	1260	1488	1694	1904	2106	2300	2486	2664	3210	3744	4326
1760S	2614S	1772S	2416S	3271S	2348S	2737S	2569S	2720S	1832S	3297S	1869S	3300S
124	**123**	**121**	**118**	**116**	**114**	**112**	**111**	**109**	**107**	**103**	**101**	**99**
744	984	1210	1416	1624	1824	2016	2220	2398	2568	3090	3636	4158
2470S	2158S	3267S	2241S	2946S	1791S	2263S	1811S	3275S	2398S	3298S	1898S	3164S
119	**118**	**116**	**114**	**112**	**110**	**108**	**106**	**105**	**103**	**100**	**97**	**96**
714	944	1160	1368	1568	1760	1944	2120	2310	2472	3000	3492	4032
2699S	2757S	2155S	1769S	2773S	1822S	2621S	2780S	2499S	2785S	2212S	1899S	2252S
135	**133**	**131**	**128**	**125**	**123**	**120**	**118**	**116**	**114**	**110**	**107**	**105**
810	1064	1310	1536	1750	1968	2160	2360	2552	2736	3300	3852	4410
2092S	2324S	2370S	1798S	2711S	2142S	1812S	2779S	3276S	1831S	2210S	2395S	2306S
128	**126**	**124**	**122**	**119**	**117**	**115**	**113**	**111**	**109**	**106**	**103**	**101**
768	1008	1240	1464	1666	1872	2070	2260	2442	2616	3180	3708	4242
1754S	2270S	2618S	2449S	2701S	1790S	2566S	2717S	3295S	1835S	2495S	2810S	3282S
121	**120**	**118**	**116**	**114**	**112**	**110**	**108**	**106**	**104**	**101**	**99**	**97**
726	960	1180	1392	1596	1792	1980	2160	2332	2496	3030	3564	4074
3288S	2271S	3290S	2196S	2318S	2628S	1816S	1812S	3303S	1888S	3280S	1897S	3283S
115	**114**	**113**	**110**	**108**	**107**	**105**	**103**	**102**	**100**	**97**	**95**	**93**
690	912	1130	1320	1512	1712	1890	2060	2244	2400	2910	3420	3906
2549S	1747S	2707S	2504S	2556S	2400S	2081S	2781S	2900S	2214S	3231S	1926S	3080S
110	**109**	**108**	**106**	**104**	**102**	**101**	**99**	**98**	**96**	**93**	**91**	**90**
660	872	1080	1272	1456	1632	1818	1980	2156	2304	2790	3276	3780
2508S	1751S	1783S	2505S	1802S	1796S	3311S	1816S	2104S	1838S	2932S	1849S	1894S
153	**150**	**148**	**144**	**141**	**138**	**135**	**133**	**130**	**127**	**122**	**119**	**116**
918	1200	1480	1728	1974	2208	2430	2660	2860	3048	3660	4284	4872
2372S	2221S	1803S	1793S	2559S	2519S	2229S	2312S	2213S	3015S	2437S	2725S	2958S
146	**145**	**142**	**139**	**136**	**133**	**130**	**128**	**125**	**123**	**118**	**115**	**113**
876	1160	1420	1668	1904	2128	2340	2560	2750	2952	3540	4140	4746
2272S	2155S	2086S	2558S	2348S	2191S	1809S	2258S	2719S	2126S	2235S	2514S	2729S
141	**139**	**137**	**133**	**131**	**128**	**125**	**123**	**121**	**119**	**114**	**111**	**109**
846	1112	1370	1596	1834	2048	2250	2460	2662	2856	3420	3996	4578
2548S	2550S	2152S	2318S	2366S	2634S	2714S	2134S	3249S	1855S	1926S	1892S	3281S
135	**134**	**132**	**129**	**126**	**124**	**121**	**119**	**117**	**115**	**111**	**108**	**106**
810	1072	1320	1548	1764	1984	2178	2380	2574	2760	3330	3888	4452
2092S	2613S	2504S	2149S	2317S	2632S	3248S	2295S	2215S	2517S	3126S	1893S	3284S
131	**129**	**127**	**124**	**122**	**120**	**117**	**115**	**113**	**111**	**108**	**105**	**103**
786	1032	1270	1488	1708	1920	2106	2300	2486	2664	3240	3780	4326
2373S	2157S	3008S	2468S	2629S	1817S	2737S	2569S	2720S	1832S	1902S	1894S	3300S

variable on a new job throws it out of the standardized tabular group. In such cases, all that it is necessary to do is to add or subtract certain sub-operation times from the standard time sheets. Table II is a typical table and is an exact copy of one of the set of 90.

214. An immense amount of detail work was necessary before the standardization of all the above variables and their

possible combinations was complete. It was necessary to take thousands of time studies. These studies had to apply to a great variety of patterns of all classes and for each of the above mentioned forms of equipment, method and flask sizes. The result of all this work has been gratifying, however.

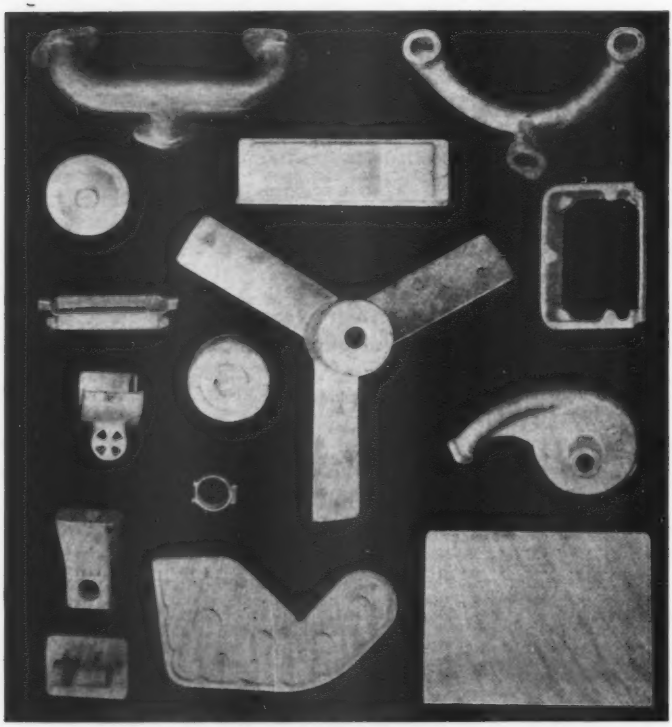

FIG. 8—A VARIETY OF SMALL WORK
Paragraph 207

215. All of the standard data has now been tabulated with the result that 95 per cent of all bench and squeezer work done by any of the six foundries of the Aluminum Castings Co. can be put on bonus direct from these tables.

This means definite and absolute standardization. Short run work can be put on bonus at once without the necessity for taking time studies on each pattern.

216. By this method it is possible to apply scientific management methods to a short job which would ordinarily run out long before a satisfactory time study could be made. The importance of this one feature alone must not be underestimated. As several of the Aluminm Castings Co. foundries do practically a jobbing business, the value of these tables can be readily appreciated.

217. This standard data has even more value in several other ways than the feature above mentioned.. In the first place there is no guess work as to the most economical combination of pattern equipment, number per mold, size of flask, method to be employed, etc. A glance at the tables tells instantly what is the best combinations to employ for each job to assure a maximum production and minimum cost.

218. Yet another great value is that of having definite data on which to base estimates. This applies both to the routine work of estimating, as well as the solving of problems of this nature by the sales representatives. This is true of both the floor, bench and squeezer data. Combining these advantages and the ability (through accurate analytical costs) to check up past performances puts a firm employing these methods in position to practically predetermine costs.

219. New equipment can be made to absolutely agree with the best standards and practice. There is no longer need to guess and try "rule of thumb" methods or "cut and dry" until we hit the right way, or the best combinations. It is impossible here to list all of the many advantages to be derived from this data. The results speak for themselves. We are finding new uses and new value in this standardized data every day it is in use.

220. All bench and squeezer jobs at both the Detroit and Cleveland plants have been put on bonus direct from these standard production data sheets for the last six months. We

have yet to find a case where the men have been unable to reach the production asked for. Neither have the maximum production figures been exceeded. The author claims that the standardization of foundry operations and practice here described marks an epoch in the history of foundry work and is in itself the vindication of scientific management in this virgin field.

14—Standard Miscellaneous Data

221. The Time Study Foreman is responsible for the following standard data. This data must be kept up to date. The list given below is subject to revision and amplification to suit varying conditions and plants.

222. Flask Data—Flasks are tools, hence come into the "T" class of symbols. Our flasks must be listed in a systematic manner in order of dimension; commencing with the smallest "T1, T2, T3, etc.," new flasks take the next number. The following shows how this list should appear:

Flask Record

Flask symbol	Pattern symbol	Quantity	Inside Dimensions L W D	Bars	Weight lbs.	Contents cubic inches	Weight with sand this pattern

Flask Record (Continued)

Net wt. sand	Weight rammed full of sand	Net wt. of sand	C-Cope D-Drag	Weight of board

223. Handling Times of Sand and Equipment—The data are accumulating on the weight of sand rammed "soft," "medium" and "hard" will allow us to determine an average weight per cubic inch or foot. The chief controlling factor in most of our work (exclusive of the standard elemental sub-operations) is the weight of sand to be shoveled and rammed, area and contour of flasks and the weight of the cope and drag complete. To these shall be added the unusual but necessary operations peculiar to certain jobs not covered by our standard production data.

224. After we have standard times on the sub-operations we will then base all our calculations on our standard of "allowable work in foot pounds per man."

225. Core Work—Standard data for this work will be similar (but much simpler) to that above mentioned in the list of standard sub-elemental operations. The chief factors to determine (for each core box of each pattern) are listed in a manner similar to that shown above for molding operations. This detail need not be repeated here.

226. Tool and Equipment Data—Keep a complete record on each time study of each job of the tools and equipment in use. Do not lose sight of the fact that the time study must include all information (or references) pertaining to each job or operation. All material and the quantities used per unit of work must be fully specified as well as the tools and equipment. This information is absolutely essential before the instruction card or bonus chart can be issued.

227. Files—File all time studies, in a vertical loose-leaf file, arranged numerically by the "time study number." Keep a 3 x 5-inch card index to the time study file, arranged by classes of work and in alphabetical and numerical order of piece symbol or other identifying mark. This card shows the complete routing for each piece as well as the bonus maximum and bonus chart number for each operation.

228. References—A general treatment of the subject of time study work will be found in "Applied Methods of Scientific Management", copy of which is on file in the planning room, and same is understood to be a part of these instructions, particularly matter on pages 147 to 166 inclusive.

229. Responsibility for Jobs on Bonus—After a satisfactory time study has been made and the time for a job determined (and the bonus list issued) the real work begins. It is up to the Time Study Foreman and his assistants to follow each new bonus job until it is going satisfactorily, both as to method, quantity and quality. They must not relax their vigilance until such time as the job reaches the maximum production called for by the Differential Bonus Chart. When this production has been reached and held for a time (*and then only*) the men themselves will see that it does not fall off through any fault of theirs.

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15—General Instructions to Time Study Men

230. The time study men must not forget that they are in the position of functional bosses and must deport themselves accordingly. In developing a position of this kind, care must be taken in setting an example to the men and by industry and ability try to raise the general standard of the shop.

231. In keeping your records, be systematic and study the symbol system as it is developed so that you will fully appreciate what is involved in the different series of symbols which will be put in use from time to time. The use of symbols means a large saving of time by greatly reducing the work, besides simplifying records.

232. In connection with your regular time study work you will be expected to report to the proper parties all matters pertaining to the violation of the shop rules. These should be carefully studied so that the time study men will be thoroughly familiar with them. Time study men can also be of material assistance to the shop employes by instructing them regarding the details specified in the rules with which they may be unfamiliar, or do not understand.

16—Parkhurst Differential Bonus

233. It is not the intention here to enter into a discussion, academic or otherwise, of the advantages of the various forms of remunerating labor. Based on the writer's experience with day work, piece work, premium and bonus, he has during the last ten years developed a differential bonus system. The differential system, as described below, has been flexible enough to be readily adaptable to any requirements put upon it. Using the same fundamental principle throughout, the application of the standard differential bonus charts is universal.

234. The author's experience has been that with properly standardized hourly rates for various grades of labor in each trade involved, the addition of a generous bonus for high production will give greater results than any other method. As he has had occasion to remark before, we pay for the employe's time, we arrange his equipment and supply a more

or less complex organization to control that equipment and the materials in process. By positive means we determine the maximum production that the average good man can turn out per day and we certainly have the privilege of utilizing the time we pay for to the best advantage and toward this end. Obviously, however, it is not fair to the worker to prevent his participating in the saving that is realized. We do this by means of increased wages (in the form of bonus) in proportion to the additional work he turns out.

235. If the employe is assured of a day's pay his mental attitude from the very start is going to be more favorable than if his pay depends entirely on what he turns out for a day's work, as under the piece work system. In a piece work shop the men are often put on strange jobs and though they work hard all day they are not able to earn more than one-third or one-half of a regular day's pay. This may go on for several days before they can make their average piece work day's pay. This obviously is unfair.

236. The premium system, though it carries a specific day rating, is not efficient in that the average methods used leave too much to the judgment and will of the individual employe. In other words, you can't get maximum production if you say to a man that his rate will be $2.50 a day and that he gets the equivalent to half (or some other proportion) of what he saves, over and above, say ten pieces per day. The tendency of this method is for everyone from the management down to tend to approximately what the man ought to do, and if this approximation is wrong it limits production, because he will not make all that he possibly can. The same thing applies to piece work where rates are incorrectly set.

237. By the adoption of standard hourly rates and differential bonus for different classes of work, combined with a proper organization, including an especially strict inspection service, you can much better control your labor and product than you can under the average piece work system.

238. Combine with the above methods accurate information as to exactly what is involved in each job, how long each

job should take based on stop watch observations; add to these an openly advertised policy that under no circumstances will you reduce a rate once set. Table 4 in section 18 indicates what the result will be.

239. To develop and standardize the differential bonus, as used by the author, he decided to provide in standard charts for fifteen different bonus classes. This classification applies to the job and not to the man. In other words, jobs are classified as belonging in bonus class 1, 3 or 8, as the case may be. Each bonus class number is equivalent to 25c per day maximum bonus for 100 per cent efficiency. Therefore, a job rated as belonging under bonus class 5 would pay $1.25 maximum bonus for 100 per cent efficiency.

240. The differential is figured on a basis of 10 per cent of the maximum bonus for 50 per cent production and 100 per cent bonus for 100 per cent production. It might be further explained here that the bonus jobs are seldom started as low as 50 per cent of the calculated maximum of production. More generally in a new shop the bonus is started at 60 or 70 per cent, depending on the local shop conditions.

241. Fig. 9 shows a standard differential bonus chart covering two charts, namely 100 and 101 units per day. The letters *A, B, C* and *D,* representing 50, 60, 70 and 80 per cent production respectively. The letter *S* represents standard production or 100 per cent efficiency. In Fig. 9 referred to, chart 100 was illustrated, so as to more readily explain the percentage basis used at the different stages of a plant's efficiency.

242. To further explain, it should be noted that local plant conditions, the class of help and other variables govern to a great extent the progress than can be made particularly. This is particularly true of the early stages of reorganization work. During these early stages, it is necessary to commence the bonus sometimes as low as 60 and sometimes as low as 50 per cent of the maximum bonus production. This statement can be more readily appreciated when one stops to consider that it is not unusual to ask for five or six times the production per day under bonus that has been the ordinary

practice of the shop under day work. If we start bonus (even though it is a small amount) at 50 per cent or 60 per cent of this maximum, we put the bonus nearer the reach of the employe. This tends to encourage him to make a little effort to demonstrate for himself whether bonus can be made or not. Of course, at this stage of his work he has the help of the Time Study Foreman to see that he does not waste time in false moves. As time goes on the average efficiency of the shop becomes higher and the starting point for new jobs can be raised to 70 per cent and later to 80 per cent of the calculated maximum. In all cases the bonus at given percentages is the same on any chart, whether it starts at 60 per cent or higher.

243. At the Detroit plant of the Aluminum Castings Co. all bonus jobs have been figured to commence at 80 per cent of the maximum bonus production. This 80 per cent factor was established Sept. 1, 1913. We have yet to find a case where the man did not earn bonus, nor have we found any case where the maximum bonus was appreciably exceeded.

244. It should be understood that the figure of 80 per cent above mentioned, means the point at which the bonus commences. On all jobs it is expected that the average workman will reach 90 per cent to 100 per cent of the maximum production. The exceptional man will go to 100 per cent and beyond.

245. This exceptional man with the ability to exceed what the average good worker can do is perfectly welcome to the extra remunerations that he gets by exceeding the 100 per cent mark. It should be noted that though the bonus charts are figured to 100 per cent production, if a man should exceed this amount by 5 or 10 per cent the differential is extended down to the figure which he actually realizes. In other words, there is no limit. Fig. 10 illustrates a typical bonus chart form FAP 117. At the time this chart was issued, all bonus commenced at 70 per cent of the maximum.

246. The success of any form of management lies in the confidence which the management is enabled to instill into the personnel. Subterfuge and excuses for changing rates must

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Standard Differential Bonus Chart. Form FAP201. Frederick A. Parkhurst, M. E. Organizing Engineer.

STANDARD DIFFERENTIAL BONUS CHARTS 100 AND 101

1 Sheet, Sheet 1 55

Bonus Production in Units per day for			BONUS CLASSES (The decimal over the bonus class figures are the differential or increment of change.)					
	Chart.	Chart.	.0045	.009	.0135	.018	.0225	.027
	100	101	1	2	3	4	5	6
A	50	51	.025	.050	.075	.100	.125	.150
	51	52	.030	.059	.089	.118	.148	.177
	52	53	.034	.068	.102	.136	.170	.204
	53	54	.039	.077	.116	.154	.193	.231
	54	55	.043	.086	.129	.172	.215	.258
	55	56	.048	.095	.143	.190	.238	.285
	56	57	.052	.104	.156	.208	.260	.312
	57	58	.057	.113	.170	.226	.283	.339
	58	59	.061	.122	.183	.244	.305	.366
	59	60	.066	.131	.197	.262	.328	.393
B	60	61	.070	.140	.210	.280	.350	.420
	61	62	.075	.149	.224	.298	.373	.447
	62	63	.079	.158	.237	.316	.395	.474
	63	64	.084	.167	.251	.334	.418	.501
	64	65	.088	.176	.264	.352	.440	.528
	65	66	.093	.185	.278	.370	.463	.555
	66	67	.097	.194	.291	.388	.485	.582
	67	68	.102	.203	.305	.406	.508	.609
	68	69	.106	.212	.318	.424	.530	.636
	69	70	.111	.221	.332	.442	.553	.663
C	70	71	.115	.230	.345	.460	.575	.690
	71	72	.120	.239	.359	.478	.598	.717
	72	73	.124	.248	.372	.496	.620	.744
	73	74	.129	.257	.386	.514	.643	.771
	74	75	.133	.266	.399	.532	.665	.798
	75	76	.138	.275	.413	.550	.688	.825
	76	77	.142	.284	.426	.568	.710	.852
	77	78	.147	.293	.440	.586	.733	.879
	78	79	.151	.302	.453	.604	.755	.906
	79	80	.156	.311	.467	.622	.778	.933
D	80	81	.160	.320	.480	.640	.800	.960
	81	82	.165	.329	.494	.658	.823	.987
	82	83	.169	.338	.507	.676	.845	1.014
	83	84	.174	.347	.521	.694	.868	1.041
	84	85	.178	.356	.534	.712	.890	1.068
	85	86	.183	.365	.548	.730	.913	1.095
	86	87	.187	.374	.561	.748	.935	1.122
	87	88	.192	.383	.575	.766	.958	1.149
	88	89	.196	.392	.588	.784	.980	1.176
	89	90	.201	.401	.602	.802	1.003	1.203
	90	91	.205	.410	.615	.820	1.025	1.230
	91	92	.210	.419	.629	.838	1.048	1.257
	92	93	.214	.428	.642	.856	1.070	1.284
	93	94	.219	.437	.656	.874	1.093	1.311
	94	95	.223	.446	.669	.892	1.115	1.338
	95	96	.228	.455	.683	.910	1.138	1.365
	96	97	.232	.464	.696	.928	1.160	1.392
	97	98	.237	.473	.710	.946	1.183	1.419
	98	99	.241	.482	.723	.964	1.205	1.446
	99	100	.246	.491	.737	.982	1.228	1.473
S	100	101	.250	.500	.750	1.000	1.250	1.500

FIGURE 9. — PARKHURST'S STANDARD DIFFERENTIAL BONUS (ONE OF A SET OF 1,000) FROM WHICH THE FIGURES FOR THE INDIVIDUAL BONUS CHARTS SHOWN IN FIGURE 10, SEE PARAGRAPH

NOTE.—S = Standard production for specific conditions, as defined by the instruction card for each job and based on accurate stop watch observations. A, B, C or D represent quantity at which bonus is to commence; once determined for a job this starting point is never changed for that job. Opposite the quantity per day will be found in each column (Bonus Class) the bonus per day in dollars and cents for that class.

BONUS CLASSES

Continued.

.0315	.036	.0405	.045	.0495	.054	.0585	.063	.0675
7	8	9	10	11	12	13	14	15
.175	.200	.225	.250	.275	.300	.325	.350	.375
.207	.236	.266	.295	.325	.354	.384	.413	.443
.238	.272	.306	.340	.374	.408	.442	.476	.510
.270	.308	.347	.385	.424	.462	.501	.539	.578
.301	.344	.387	.430	.473	.516	.559	.602	.645
.333	.380	.428	.475	.523	.570	.618	.665	.713
.364	.416	.468	.520	.572	.624	.676	.728	.780
.396	.452	.509	.565	.622	.678	.735	.791	.848
.427	.488	.549	.610	.671	.732	.793	.854	.915
.459	.524	.590	.655	.721	.786	.852	.917	.983
.490	.560	.630	.700	.770	.840	.910	.980	1.050
.522	.596	.671	.745	.820	.894	.969	1.043	1.118
.553	.632	.711	.790	.869	.948	1.027	1.106	1.185
.585	.668	.752	.835	.919	1.002	1.086	1.169	1.253
.616	.704	.792	.880	.968	1.056	1.144	1.232	1.320
.648	.740	.833	.925	1.018	1.110	1.203	1.295	1.388
.679	.776	.873	.970	1.067	1.164	1.261	1.358	1.455
.711	.812	.914	1.015	1.117	1.218	1.320	1.421	1.523
.742	.848	.954	1.060	1.166	1.272	1.378	1.484	1.500
.774	.884	.995	1.105	1.216	1.326	1.437	1.547	1.658
.805	.920	1.035	1.150	1.265	1.380	1.495	1.610	1.725
.837	.956	1.076	1.195	1.315	1.434	1.554	1.673	1.793
.868	.992	1.116	1.240	1.364	1.488	1.612	1.736	1.860
.900	1.028	1.157	1.285	1.414	1.542	1.671	1.799	1.928
.931	1.064	1.197	1.330	1.463	1.596	1.729	1.862	1.995
.963	1.100	1.238	1.375	1.513	1.650	1.788	1.925	2.063
.994	1.136	1.278	1.420	1.562	1.704	1.846	1.988	2.130
1.026	1.172	1.319	1.465	1.612	1.758	1.905	2.051	2.198
1.057	1.208	1.359	1.510	1.661	1.812	1.963	2.114	2.265
1.089	1.244	1.400	1.555	1.711	1.866	2.022	2.177	2.333
1.120	1.280	1.440	1.600	1.760	1.920	2.080	2.240	2.400
1.152	1.316	1.481	1.645	1.810	1.974	2.139	2.303	2.468
1.183	1.352	1.521	1.690	1.859	2.028	2.197	2.366	2.535
1.215	1.388	1.562	1.735	1.909	2.082	2.256	2.429	2.603
1.246	1.424	1.602	1.780	1.958	2.136	2.314	2.492	2.670
1.278	1.460	1.643	1.825	2.008	2.190	2.373	2.555	2.738
1.309	1.496	1.683	1.870	2.057	2.244	2.431	2.618	2.805
1.341	1.532	1.724	1.915	2.107	2.298	2.490	2.681	2.873
1.372	1.568	1.764	1.960	2.156	2.352	2.548	2.744	2.940
1.404	1.604	1.805	2.005	2.206	2.406	2.607	2.807	3.008
1.435	1.640	1.845	2.050	2.255	2.460	2.665	2.870	3.075
1.467	1.676	1.886	2.095	2.305	2.514	2.724	2.933	3.143
1.498	1.712	1.926	2.140	2.354	2.568	2.782	2.996	3.210
1.530	1.748	1.967	2.185	2.404	2.622	2.481	3.059	3.278
1.561	1.784	2.007	2.230	2.453	2.676	2.899	3.122	3.345
1.593	1.820	2.048	2.275	2.503	2.730	2.958	3.185	3.413
1.624	1.856	2.088	2.320	2.552	2.784	3.016	3.248	3.480
1.656	1.892	2.129	2.365	2.602	2.838	3.075	3.311	3.548
1.687	1.928	2.169	2.410	2.651	2.892	3.133	3.374	3.615
1.719	1.964	2.210	2.455	2.701	2.946	3.192	3.437	3.683
1.750	2.000	2.250	2.500	2.750	3.000	3.250	3.500	3.750

CHART FOR 100 AND 101 UNITS PER DAY. THIS IS A MASTER TABLE VARIOUS BONUS CLASSES MAY BE TAKEN WHEN MAKING THE 241.

be absolutely avoided. The writer has always made it a point never to lower a bonus rate once established. This policy is openly published in the shop rules with concerns he has been identified with. He owes the success of his methods in a great measure to the fact that the personal factor has been of paramount consideration with him and all of those who come in contact with him and his methods know that prices will not be lowered, providing of course the equipment and method remains unchanged. Furthermore, he uses no "excursion rates." A job once set is fixed forever.

247. In order not to leave a wrong impression regarding the closing sentence of the preceding paragraph, a word of explanation is desirable. We are continually being confronted with slight changes in pattern equipment or methods that theoretically and fairly would even call for the revision of the bonus prices. Where this change of equipment does not make any material difference, say only 5 or 10 per cent, we in the majority of cases let the original bonus chart stand. We are very careful not to take advantage of any slight alteration of equipment to reduce a price. We are also careful to let the man realize that the entire scheme of management from start to finish is one that contemplates fair treatment to him.

248. The writer can cite cases of where the head man of a molding gang has asked for an additional laborer to dump out, stating if this man was supplied he could raise his day's production from 70 to 77 molds. This was done on one particular job and the job ran for weeks at the average of over 76.2 good castings per day. The production of 76.2 castings, referred to, under bonus represents an increase of 103 per cent over the old piece work production, which averages 37.5 castings per day. This same man asked to be told a day before the pattern was to go out of the sand so that he and his gang could put up a record that no other gang could touch. It is spirit of this kind which spells co-operation and harmony and gives the greatest results under any form of management.

Bonus Chart. Form FAP117 The Aluminum Castings Co.

BONUS CHART 138—1 SHEET, SHEET 1

Instruction No..... Date, March 8, 1913

NOTE—The following prices will be paid as Bonus in addition to hourly wages based on Good Pieces which pass in after this specific operation, except that Defective not due to work specified on this Chart will not be deducted in paying Bonus.

These Bonus Prices will not be lowered no matter how long the job may run with this pattern, core boxes, equipment and by the method and design specified in the instruction referred to and with the number of operatives mentioned below.

OPERATION—Molding.
SYMBOL—AA-3576.
CUSTOMER—The Studebaker Corporation.
EQUIPMENT—Drag on Power rollover machine; cope on horses ram up 13 flat chills in cope; also tuck bars, ram and step off.
OPERATIVES AND CLASS NO.—1 Molder, Class 7; 2 Helpers, Class 5.

Good Castings.	Bonus, Class 5.	Bonus, Class 7.	Good Castings.	Bonus, Class 5.	Bonus, Class 7.
140	.575	.805	171	.924	1.293
141	.586	.821	172	.935	1.309
142	.598	.837	173	.946	1.325
143	.609	.852	174	.958	1.34
144	.62	.868	175	.969	1.356
145	.631	.884	176	.98	1.372
146	.634	.90	177	.99	1.388
147	.654	.915	178	1.003	1.404
148	.665	.931	179	1.014	1.419
149	.676	.947	180	1.025	1.435
150	.688	.963	181	1.036	1.451
151	.699	.978	182	1.048	1.467
152	.71	.994	183	1.059	1.482
153	.721	1.01	184	1.07	1.499
154	.733	1.123	185	1.081	1.514
155	.744	1.041	186	1.093	1.53
156	.755	1.057	187	1.104	1.545
157	.766	1.073	188	1.115	1.561
158	.778	1.089	189	1.126	1.577
159	.789	1.104	190	1.138	1.593
160	.80	1.12	191	1.149	1.608
161	.811	1.136	192	1.16	1.624
162	.823	1.152	193	1.171	1.64
163	.834	1.167	194	1.183	1.656
164	.845	1.183	195	1.194	1.671
165	.856	1.199	196	1.205	1.687
166	.868	1.215	197	1.216	1.703
167	.879	1.23	198	1.228	1.719
168	.89	1.246	199	1.239	1.734
169	.901	1.262	200	1.25	1.75
170	.913	1.278	...	.....	.....

FIGURE 10.—BONUS CHARTS ISSUED TO EACH EMPLOYE (OR GROUP OF EMPLOYES). THE FIGURES ARE TAKEN FROM THE STANDARD DIFFERENTIAL BONUS CHARTS ILLUSTRATED IN FIG. 9, SEE PARAGRAPH 245.

249. Reference to Table IV in section 18 will give an idea of the majority of foundry operations covered by the differential bonus being described. These same principles have been applied, however, to miscellaneous work, such as removing large quantities of dirt, in one instance a pile containing 2,700 cubic yards. Reconstruction work has also been handled on the same basis of remuneration. In other words, the entire scheme of bonus contemplates the application of this method of remuneration to practically everyone within the organization.

250. Another application may be described in reference to a bonus scheme, which has been worked out for the remuneration of the inspection force. This is termed "quality bonus". Figures have been determined representing what the 100 per cent mark for quality would be for each of the following factors:

A Foundry Defective Castings.
B Total Cost of Repairing, Soldering and Welding.
C Percentage of Defective Castings returned from customers.

252. The figures which have been determined for each of the above items A, B and C, represent an efficiency mark applicable to quality which nets all of the inspectors a maximum bonus. The differential of this bonus is figured in exactly the same way as described above for other work. If the above marks are realized to the extent of 80 per cent of the maximum, the bonus commences and by the usual differential grades along to the 100 per cent mark.

253. Another interesting application of this differential bonus method of payment, is the application of this principle to brass melting in the coke furnaces in the Detroit plant of the Aluminum Castings Co. This same method will be applied to the brass melting in the Cleveland plant by the end of the year.

254. The following is a copy of the differential bonus chart 3574D covering the details of this brass melting bonus. The description of the way this is handled, as shown by the chart referred to, is self explanatory.

Bonus Chart No. 3574D

Differential Bonus for Melting Lynux Metal

255.

The following prices, based on man-furnace hours per heat, will be paid in addition to hourly wages for time consumed on the job by the Lynux melting gang, based on a 12-hour furnace day.

256.

The metal will be sent to the furnaces in weighed charges. It is to be melted and delivered to skimming box (ready for the pouring gang) at a pouring temperature high enough for the class of work for which it is intended.

257.

Furnaces are to be operated on natural draft, using coke as fuel, which coke will be delivered into bins back of furnaces, but is to be broken by the melting gang. A half hour will be allowed for building a fire. Power hoists have been provided for lifting the pots from furnaces.

258.

The different kinds of Lynux are to be graded by the foreman according to time required for melting and a chart will be issued showing the "equivalent in standard heats" for any number of pounds of the various grades. The standard heat is regarded as grade 6—240 pounds in two hours.

259.

The computation for "man-furnace hours per heat" is to be made as follows:

(1) Compute from the daily job time cards the total man-hours spent by the melting gang.

(2) The sum of the hours which each individual furnace runs will give the total furnace hours.

(3) For each heat melted compute from the table its "equivalent in standard heats" and the sum of these gives the total standard heats.

(4) (3½ total man-hours) + total furnace hours = total man-furnace hours.

(5) $\frac{\text{Total man-furnace hours}}{\text{Total standard heats.}} = \text{Man-furnace hours per heat.}$

260.

Delays caused by conditions beyond the control of the melting gang will be allowed for. These prices will not be changed, as long as present conditions of operation remain the same.

261.

Differential

Bonus Class 5—0.01406; *Bonus Class* 6—0.01687

Bonus based on man-furnace hours per standard heat as computed from record of daily charges and heat equivalent table. (See Table III.)

Man furnace hrs. per heat.	Melters' bonus Class 6.	Each Helper bonus Class 5.	Man furnace hrs. per heat.	Class 6.	Class 5.
5.00	$1.162	$ .969	4.50	$1.331	$1.109
4.95	1.179	.983	4.45	1.348	1.123
4.90	1.196	.997	4.40	1.365	1.137
4.85	1.213	1.011	2.35	1.382	1.151
4.80	1.230	1.025	4.30	1.398	1.165
4.75	1.247	1.039	4.25	1.415	1.179
4.70	1.263	1.053	4.20	1.432	1.194
4.65	1.280	1.067	4.15	1.449	1.208
4.60	1.297	1.081	4.10	1.466	1.222
4.55	1.314	1.095	4.05	1.483	1.236
			4.00	1.500	1.250

262. In computing the bonus each day reference has to be made to the Brass Furnace Heat Equivalent Table 2 herewith. The Daily Metal Room Report gives a record of each different alloy number. Each alloy number belongs in one of the metal groups 5 to 10 inclusive. The sum of the equivalent heat figures for each group melted each day divided into the total man furnace hours for that day gives the man furnace hours per heat.

TABLE III

BRASS FURNACE "HEAT" EQUIVALENT TABLE

(Used in connection with Differential Bonus Chart No. 3574D Lynux Melting Practice)

1. Standard Heat—240 lb. charge, Group 6 in 2 hours.

Pounds per charge.	Standard Heat Equivalents—Metal Group					
	5	6	7	8	9	10
5	.30	.25	.214	.082	.052	.129
10	.42	.35	.300	.100	.056	.133
15	.48	.40	.343	.117	.059	.137
20	.54	.45	.386	.133	.062	.141
25	.552	.46	.394	.150	.066	.145
30	.565	.47	.403	.153	.069	.149
35	.582	.485	.416	.156	.073	.153
40	.600	.500	.428	.159	.076	.157
45	.615	.512	.438	.162	.079	.162
50	.630	.525	.450	.166	.082	.166
55	.645	.537	.460	.169	.085	.170
60	.660	.550	.472	.173	.089	.174
65	.675	.562	.482	.176	.092	.178
70	.690	.575	.493	.180	.096	.183
75	.705	.587	.503	.183	.099	.187
80	.720	.600	.514	.186	.103	.191
85	.735	.612	.525	.190	.106	.195
90	.750	.625	.536	.193	.110	.199
95	.765	.637	.546	.197	.113	.204
100	.780	.650	.557	.200	.117	.208
105	.795	.662	.568	.203	.120	.212
110	.810	.675	.578	.206	.124	.216
115	.825	.687	.589	.210	.127	.220
120	.840	.700	.600	.213	.130	.225
125	.855	.712	.611	.216	.133	.229
130	.870	.725	.622	.219	.137	.233
135	.885	.737	.632	.223	.140	.237
140	.900	.750	.643	.227	.143	.241
145	.915	.762	.654	.230	.147	.246
150	.930	.775	.664	.234	.150	.250
155	.945	.787	.675	.237	.153	.254
160	.960	.800	.686	.240	.157	.258
165	.975	.812	.696	.244	.160	.262
170	.990	.825	.707	.247	.163	.267
175	1.005	.837	.718	.250	.166	.271
180	1.020	.850	.728	.253	.170	.275
185	1.035	.862	.739	.256	.173	.279
190	1.050	.875	.750	.260	.176	.283
195	1.065	.887	.760	.263	.180	.288
200	1.080	.900	.771	.266	.183	.292
205	1.095	.912	.782	.269	.186	.296
210	1.110	.925	.792	.272	.190	.300
215	1.125	.937	.802	.276	.193	.304
220	1.140	.950	.813	.279	.196	.309
225	1.155	.962	.824	.282	.200	.313
230	1.170	.975	.834	.285	.203	.317
235	1.185	.987	.845	.288	.206	.321
240	1.200	1.000	.857	.291	.210	.325

263. The combination of man hours and man furnace hours enables us to maintain a minimum of labor and assures the use of a minimum number of furnaces per day. Otherwise, additional furnaces might be fired up to get a few extra heats at an excessive cost for fuel. The method has been in vogue for several months and has worked out very successfully. Figures in the heat equivalent table are based on the results of actual time studies for the various groups of metal and for varying charges. These figures check out very close in practice and the first day the furnace gang worked on this schedule they earned bonus.

264. Fig. 11 shows a very interesting large crank case job run on the floor under bonus early in 1912. The record of this job during 38 days' run—four duplicate sets of equipment, is as follows:

Pat. No.	Net good.	Total hours.	Overtime.	No. days.	Av. good per 9 hr. day.	Molders good.	Daily wage.	Daily wage, Bonus.	Total cost.	Cost per good case.
1	1,039	3,395.0	0	37.72	27.55	28.6	$23.27	$ 9.121	$33.391	$1.175
2*	1,140	3,268.5	0	36.31	31.40	32.2	25.64	12.926	38.566	1.228
3	1,042	3,398.5	0	37.64	27.70	29.1	23.06	9.607	32.667	1.180
5	984	3,310.0	0	36.77	26.75	28.3	24.06	8.832	32.882	1.230
	Averages of four patterns				28.35	29.55	$24.005	$10.121	$34.126	$1.203

265.

*Gang on pattern No. 2 was a picked gang considered the fastest and best workers in the shop, always worked together and received extra high wages owing to their efficiency.

266.

Old average good production under combination of day wages and premium—15.15 cases.

Old average good production cost under combination of day wages and premium—$1.196 per case.

Bonus average production increase, 87.2 per cent per case.
Bonus average cost increased $0.007 per case.

267.

This is an example of an occasional case where the direct labor cost is not reduced. The saving is thus confined to less overhead and greater capacity due to increased production.

268.

Old foundry defective from all causes when netting 15.15 good cases per day was 25 per cent.

Foundry defective from all causes under intense bonus production when netting 28.35 good cases per day was but 9.83 per cent.

Foundry defective loss under intense bonus production and Scientific Management methods was reduced 60.7 per cent.

Average bonus equals 42.2 per cent over regular day wages.

269. Fig. 12 shows a typical core job, on which the average daily production is 1,305 cores per nine-hour day. The core illustrated is a Packard hub cap core.

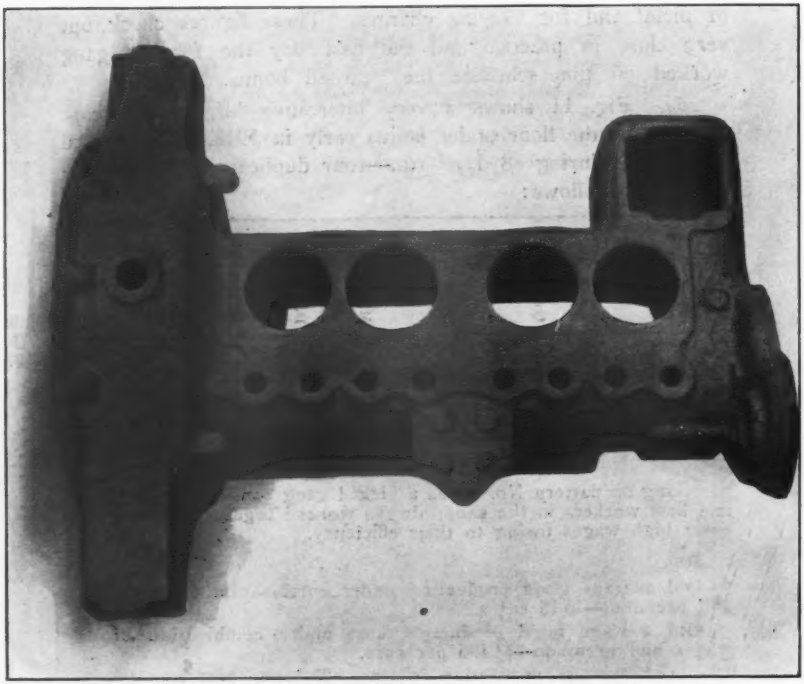

FIG. 11—FOUR CYLINDER CRANK CASE JOB RUN ON THE FLOOR
Paragraph 264

270. Fig. 13 represents another large floor job. This is a four-cylinder oil pan for which three sets of equipment were made to assure the customer of a production of 75 good castings per day. A great many thousand of these pans have

been made of this design. The average production runs from 108 to 115 molds per nine-hour day.

271. Another typical core job is illustrated in Fig. 14. This is a transmission bearing core and the average production is 1,620 cores per nine-hour day.

272. Fig. 15 illustrates a transmission job run by a molding gang of four men and two laborers employed in dumping out and cutting sand. The production on this job averages 160 to 180 good castings per nine-hour day.

273. Fig. 16 illustrates a typical bench job. This is an intake manifold, on which the average production is 150 molds per nine-hour day. Work of this kind, as well as all other bench and squeezer work is covered by the standard data described in Section 13. Fig. 8 referred to in Section 13 illustrates a small variety of the work covered by these standard tables.

274. Before closing with the subject of the application of differential bonus, attention is called to Table IV. The object of listing so many different items rather than expressing the results obtained in total lump figures, is to show up the great difference in production increases and cost decreases between different jobs. In other words, it will be noted that production increase runs from only a few per cent to over 700 per cent. The figures in the cost decrease column in a few instances show practically no decrease in cost and in others the decrease is 80 or more per cent. These figures illustrate better than can be done in any other way, the great variations that exist in the average job, both as to the production standard and direct costs. In other words, under ordinary methods, it is comparatively easy for jobs to be limited in production due to the apparent similarity between one job and another. These figures also show up the great difference between what in the judgment of the average good mechanic should be a day's work and what actually should be realized when the facts are accurately determined.

275. In studying over the figures representing the percentage of cost reduction, as shown in Table IV, it can be seen that there is a very wide difference on some jobs between

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the production increase and the cost decrease. In other words, in some cases the cost decrease is very little and the production increase is very high. We also have the reverse condition where the cost decrease is high and the production increase is much lower. All of these go to prove the necessity which the job should run, as well as the proper balance of labor required to run that job efficiently.

17—Inspection

276. The next most important branch of the organization is Inspection. Though we may have completely developed and under control our office and sales departments, a properly operating Planning Room, routing and controlling orders, material and labor, and a well maintained plant, these all become useless without the continual supervision of the inspection department.

277. Inspection must control, to the smallest detail, all of the various operations from the first inspection of the design to the completion and shipment of the last piece on a customer's order. This is particularly true when we begin to realize intense production and where, in addition to an hourly rate, we pay a large bonus for extra production. Under these conditions the most rigid inspection is necessary.

278. The subject of inspection will be discussed in order of the following divisions:

279.

A—Designing (281).
B—Detailed drawings (285).
C—Complete pattern equipment (291).
D—Sample cores, mold and casting (294).
E—Laboratory control of mixtures and pouring temperature (299).
F—Balance of labor (302).
G—Details of method (303).
H—Production standards based on time study (305).
I —Routine production inspection, including—(306).

280.

a—Pattern equipment.
b—Cores.
c—Molds.

d—Pouring temperatures.
e—First inspection of casting—hot.
f—Knockout inspection.
g—Trimming inspection.
h—General inspection.
i—Final inspection.
j—Service inspection (312).
k—Inspection Committee.

FIG. 12—GIRL MAKING HUB CORES
Paragraph 269

281. Consideration of the design in connection with a customer's engineering department represents the first touch of inspection pertaining to that customer's order. It is often times possible, by consultation with the customer's engineer, to co-operate toward a simplification of design or change of

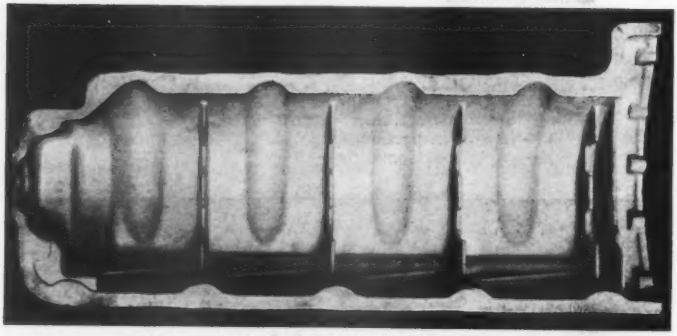

FIG. 13—LARGE FOUR CYLINDER OIL PAN
Paragraph 270

FIG. 14—GIRL MAKING BEARING CORES
Paragraph 271

sections, or a combination of both. Two heads are better than one.

282. The promotion of the above method can but result in eliminating many causes for loss and delay, when the design in the form of a pattern finally reaches the foundry.

283. There is a double advantage following this method of preliminary inspection in connection with a foundry that has highly developed operating methods. Such methods give the designing engineer access to a great deal of data covering past experiences that cannot help but be of great advantage to him in connection with future work.

284. Of course the foundry's engineer is the medium through which the customer's engineer and designers get their benefit of the best foundry practice.

285. A more critical inspection now takes place when the detailed drawing for an individual piece is ready for the pattern shop. At this stage we have to consider a great many different things that we but superficially touch upon when the general designing inspection (see 281 above) was made.

286. Before proceeding with the pattern equipment there are a great many things to consider. These different items include, quantity to be made from a pattern, foundry method to be employed, cost of the pattern equipment for various molds where a choice is possible, method of rigging up, gating, flask equipment, etc.

287. If the pattern under consideration is a cored job we have to consider the style and arrangement of core boxes. This brings us down to a minute consideration of the design and proportions of the pattern. This inspection often leads to a modification in design or proportion overlooked at the time of the first inspection.

288. When considering the matter of equipment the members of the factory board are often represented in a discussion as to these details. It is also important that the Superintendent, Time Study Foreman and Foundry Foreman should work together toward a settlement of these preliminaries.

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FIG. 15—A TYPICAL TRANSMISSION CASE, FLOOR JOB
Paragraph 272

289. Too much stress cannot be laid on the fact that pattern equipment (excepting perhaps in relation to large production jobs) does not as a rule have the careful attention that it should. The average foundry does not know what is the best combination of flask dimensions (based on scientific knowledge) to get the greatest tonnage from a given pattern. This statement applies to jobs which may be run from either

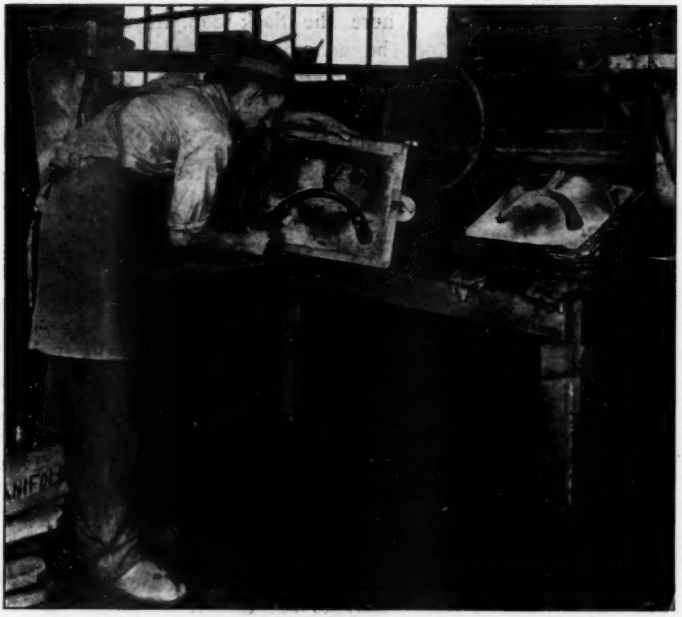

FIG. 16—MANIFOLD, BENCH JOB
Paragraph 273

a solid or split pattern, or a gated pattern, or a plated pattern. In other words, there is an ideal combination for every job. These jobs cannot be intelligently and economically planned, and pattern equipment cannot be properly made without the accurate standard data and production knowledge which can only be determined by scientific methods.

290. On bench and squeezer work we have also to consider those jobs which require matches. The design of the match and method of its construction have a very material effect on the job when it reaches the foundry.

291. A consideration of the items mentioned above in paragraph 285 gives us the full knowledge to prepare our complete pattern equipment. This pattern equipment, as the term is used, means not only patterns and core boxes but core dryers, matches, etc. Where the flask equipment is special and the patterns cannot be adapted to standard flasks and boards, then this equipment should also be considered as part of the pattern equipment—likewise machine equipment.

292. The machine equipment, the standard and often used for many jobs, represents part of a given pattern equipment, provided such equipment is designed to run on that machine.

293. At all stages of the work through the foundry continual inspection must be maintained of core boxes, dryers, pattern equipment, flasks and machines. If this inspection becomes lax we may continue to make cores which the molder has to file a bit or we may be tied up for production due to lack of a certain number of core dryers. In other words, there is much more to the subject of inspection of pattern equipment than merely the inspection of a new pattern. This inspection must be continuous—patterns must come out of the sand at night, be inspected and perhaps "touched up" before production starts in the morning. The flasks must be watched to see that there is no shift in the pins—core boxes must be examined periodically to see that loose pieces do not "ram off" or become misplaced due to wear or distortion.

294. Regular shop inspection on work produced first takes place at the time sample castings are made. Here we have to consider the inspection of cores, mold and casting. The cores should be inspected in the core room and when necessary gages should be provided to assist in inspection as to size and shape. When making sample castings it is well to order two or three sets of cores. This method will expe-

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dite making of samples in the event the first one or two castings are lost.

295. The inspection of the mold is the next step. This inspection should take place before the mold is cored up. At this point we have to consider the action of the pattern to see that it draws properly. If the pattern does not have proper draft or if there is something wrong with the rigging we have a torn-up mold. This should be corrected at once and another mold tried out until we get the pattern working in satisfactory shape. When we have a perfect mold we are then ready to provide a necessary gating, after which the mold is ready to core up.

296. In setting cores in the first mold every core should be carefully inspected as to size and fit. The "setting" must be inspected to see that the core prints and cores match properly—that the core settles into position and that we have a proper thickness of metal as per the blue print. A detail blue print of the piece in question should be on the floor at the time the sample casting is made. This is particularly important where the job is a large floor job or a complicated piece.

297. Based on past experience by consulting records of pouring temperatures of similar castings the correct pouring temperature for the first casting will be determined. After the mold is poured and dumped out an inspection of the casting will indicate as to whether the mold was poured at the correct temperature or not. Of course, this may not become definitely known until after the cores are knocked out and the casting chipped. In any event the first one or two castings poured will allow us to determine the correct pouring temperature. When this has once been determined all of the subsequent castings will be poured at that temperature, within an allowable variation of a few degrees. (See Fig. 17.)

298. The sample as soon as poured should be "knocked out" passed through the trimming and inspection departments (see Figs. 18 and 19) and checked by the Chief Inspector to see that it agrees with the drawing. After this has been done

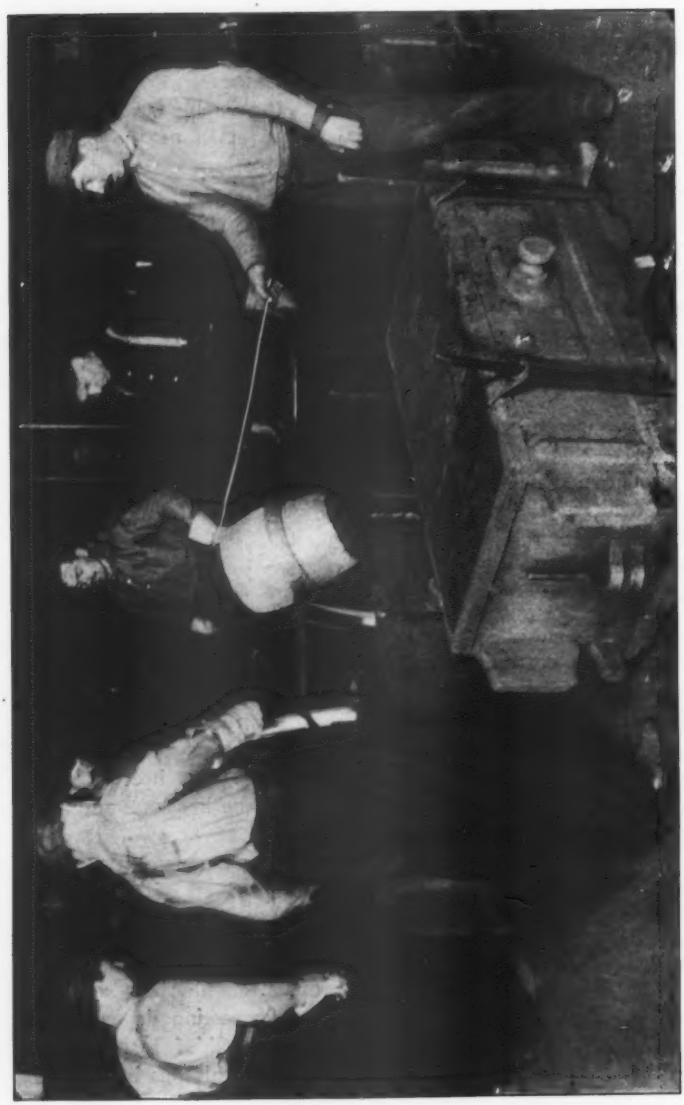

FIG. 17—POURING GANG POURING HEAVY FLOOR WORK
Paragraph 297

it is ready for delivery to the customer provided it is passed in quality, workmanship and size by the Chief Inspector. All sample castings are marked with a tag and directed to the attention of the party at the customer's plant who is to give it the first inspection and O. K. A written approval of the sample casting is required before the foundry proceeds with production.

299. Prior to the pouring of the casting as described in 294, laboratory control exerts its influence. In other words, the mixture is determined and the laboratory control of melting and pouring assures the best practical results in the pouring of the casting itself.

300. All molds are poured by a specially trained gang. The pouring gang as well as the furnace men and melters are under the general supervision of the Chief Chemist in so far as the technical part of their work is concerned. By this method we eliminate labor and delays caused by the molder pouring his molds himself. We are also able to restrict the responsibility for a proper melting temperature and pouring to technically trained men rather than to the average run of untrained mechanics. (See Fig. 17.)

301. Laboratory control as above described in itself represents another very important form of inspection. In other words, through laboratory control we have a study of alloys and inspection of mixture and pouring temperatures.

302. The balance of labor is pre-determined by our Time Study Foreman and our standard production data. When production is realized, based on given equipment, and a check on the quality of the work turned out, it gives us a continual check on our labor. The "man days" worked on a given production at a prevailing average rate per man day for different classes of labor, checked against our cost control chart gives us the equivalent of an inspection control on all labor expended.

303. In addition to the general labor control, as explained above in 302, we have the detail inspection of method. This inspection of method consists of the detailed time study into

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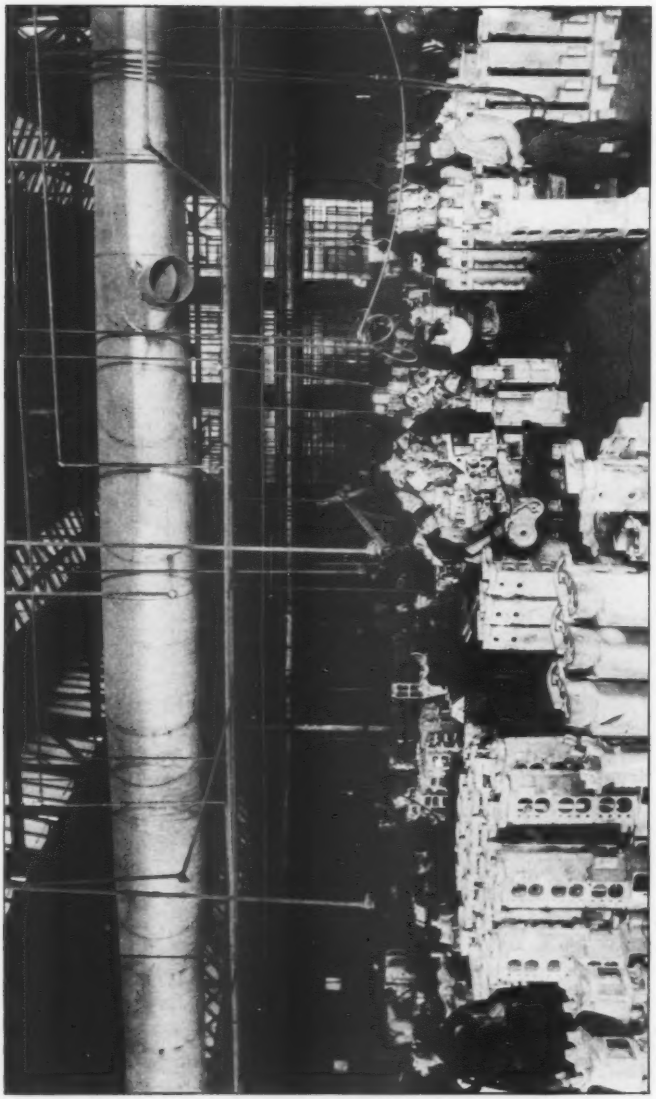

FIG. 18—TRIMMING AND INSPECTION ROOM WITH A CAPACITY OF 50,000 POUNDS OF ALUMINUM CASTINGS PER DAY
Paragraph 298

the motions and times of operations. All standardized operations are made up of sub-operations or elemental sub-operations. The elemental sub-operations have been standardized and standard times determined for them. These determinations provide for certain combinations to meet any of our standard methods.

FIG. 19--HYDRAULIC TEST AND FINAL INSPECTION OF INTAKE MANIFOLDS AND PIPES
Paragraph 298

304. The inspection of equipment and the determination of the method combined with our standard production data gives us a perpetual control and inspection of these methods while each job is in process.

305. After determining the balance of labor in the detailed method described above in 302 and 303, the time study foreman issues the necessary instructions and Bonus Charts to cover the details of the job in process. As mentioned in 303 our standard data give us the basis for all of this information, though certain individual time studies may

be necessary to take care of any special features peculiar to that job. This time study work includes the time study necessary to put on bonus core making (each individual box is figured separately) molding, knocking out, trimming and inspection and any other operations involved in the process.

306. In paragraphs 281 to 305, inclusive, we have discussed the various divisions of work necessary to get a foundry job in condition to run. After the submission of the sample and a written O. K. from the customer we are then prepared to run the job on a production basis. The routine inspection of the job while it is in process for production is very similar to that outlined above. In other words, to sum up the above we have during production the following stages of production, viz.—

307.

Inspection of—a—Pattern equipment.
b—Cores.
c—Molds.
d—Pouring temperature and laboratory control.
e—First inspection—hot casting.
f—Knockout inspection.
g—Trimming room inspection.
h—General inspection.
i—Final inspection.

308. Applying to certain of the above stages of inspection we must, of course, have drawings, gages or other standards to which inspection shall be made. The use of gages is desirable in both core and molding rooms. They are also equally desirable in many cases in the trimming and final inspection rooms, although the entire field under discussion is considering only rough castings, not machining operations.

309. As stated at the commencement of this section on inspection it is absolutely necessary that the various stages of the work in process shall have careful inspection along the lines indicated above. There can be no economy in a delayed core inspection with the resultant loss of a lot of cores; nor a delay in the first "knockout" inspection when the casting is hot. The foundry is liable to run ahead with a large production before the defect becomes known. Often defects will be discovered after the casting has reached the trimming

table. Oftentimes there will be a strain in the casting which, though not sufficient to break it at once, will cause it to fracture under the ordinary vibration it gets in knocking out cores and during the process of trimming. Here we have a defect, the discovery of which was delayed.

310. Prompt action is necessary to report all defects back to the molding room or the laboratory, as the case may be. Sometimes a slight difference in the run of metal will cause a crack and it is up to the laboratory to immediately run down this trouble.

311 We must realize the necessity for continuous control of operations, particularly where the men are working at high speed and are making large bonuses. When men have been trained to do their work with a minimum of motion and exertion, keeping their minds and hands continually on the job, with proper inspection control the required production can be realized with an A-1 quality. This statement is not based on any theoretical proposition but on absolute facts and experience of years. The writer has one large foundry in mind where his methods tripled the production and reduced the defective loss 60 per cent.

312. We now come to the last word of inspection service, viz.—the Service Inspector. The success of service inspection depends primarily on two things—one the inspector himself, the other the plant behind him. The Service Inspector while primarily a shop man by training and experience, should be a member of Sales Department when the ultimate scheme of organization is complete.

313. It shall be the service inspector's duty to keep in touch with all of the customers, particularly the larger ones, so as to learn as early as possible all of their complaints. He must of course keep in touch with the foundry during his daily trips. This is particularly true where continuous pouring is the practice and the foundry is run solely as a jobbing business.

314. If the Service Inspector is a practical man he can go into the customer's plant and co-operate with the customer's inspectors and mechanics. His service will prove to be one

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that is mutually beneficial. It is only too true that complaints based on some small minor trouble or defect often reach "those higher up," which if given prompt attention in the first place by the foundry would never have developed into a complaint at all.

315. The more thorough knowledge a foundry has through its service inspector of the requirements of the customer, the accuracy he requires, the better the service. Service Inspection is necessary too so that the foundry can tell just what part of the work must have particular attention and be held to close limits and what part will stand a greater allowance of variation.

316. The writer believes that the average reader will agree with him when he states there is too little harmony between the average foundry and the average machine shop. Each thinks the other is wrong. It is undoubtedly true however that the foundry and machine shop heads are oftentimes not sufficiently familiar with each other's trades to allow them to work together to the best advantage. Where this condition obtains the service inspector, though perhaps in an unenviable position, has the opportunity to make himself doubly valuable. The advantage of such a service is obvious if the right man is chosen for this most important position.

317. The purpose of the inspection committee can best be described by referring to the copy of complete instruction. See Appendix, Instruction LXXX, Section 23.

18—Results Obtained Under the Above Methods

318. The following (see Table IV) will indicate the result that can be expected by the proper application of the methods described above. Over 400 operations are listed below. At the present time bonus data has been issued for about 2,000 operations. All of these operations are based on time studies. In addition to the operations mentioned above 1,656 standard bonus charts have been established. These standard charts are applicable to over 36,000 combinations of bench and squeezer work. This data covers 95 per cent of the work done by any of the six foundries of the Aluminum Castings Co.

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319. The missing item numbers in Table IV were omitted due to the absence of comparative figures. This is chiefly due to the fact that nearly all of the missing items never "ran" except under bonus. In all cases average figures are taken—not extremes. Some jobs are run by one man (or one girl, in case of small cores) and others by several men in gangs. Some of the jobs listed represent the work done by men in gangs. Some gangs have as many as 10 men employed on one set of patterns. In all cases the direct labor cost represents the total money paid to all of those working on the job, figured on a basis of a nine-hour day.

320. Following is a key to the symbols used in Table IV.

321.

MC—Making Cores
MD—Molding
CP —Chipping
UD—Unloading (tons)
FI —Filing
GR —Grinding
KG—Knocking off Gates
KO—Knocking out Cores
SV —Shoveling (tons)

TABLE IV

TABLE OF PRODUCTION AND DIRECT LABOR COST COMPARISONS

		Old Method — Including Day, Piece and Premium Work.			New Method — Under Scientific Management and Differential Bonus.				
Item.	Operation.	Good pieces per day.	Total cost.	Cost per good piece.	Good pieces per day.	Total cost.	Cost per good piece.	Good prod., increase, per cent.	Cost reduced, per cent.
1	MD	30.9	$11.79	$ .382	54.	$17.18	$ .318	75.	16.8
2	MD	34.	13.43	.395	66.7	19.50	.293	96.	25.8
3	MD	22.62	9.75	.430	65.6	18.26	.278	190.	35.4
4	MD	74.	8.36	.113	112.	11.16	.099	51.3	12.4
5	MD	14.25	16.24	1.140	16.33	19.50	1.193	14.5	4.7
6	MC	40.	4.80	.120	65.	5.21	.080	62.	33.3
7	MC	42.5	4.46	.105	55.	3.68	.067	29.2	36.2
8	MC	42.5	4.25	.100	55.	4.43	.081	29.2	19.
9	MC	42.5	4.68	.110	55.	3.93	.072	29.2	34.5
10	MC	42.5	3.83	.090	55.	4.43	.081	29.2	10.
11	MC	42.5	3.83	.090	55.	4.43	.081	29.2	10.
12	MC	42.5	4.25	.100	55.	3.60	.065	29.2	35.
13	MC	93.	5.12	.055	90.	3.31	.037	3.2	32.7
14	MC	58.	5.51	.095	80.	4.08	.051	38.9	56.8
15	MC	50.	2.00	.040	110.	3.10	.028	120.	30.
16	MD	29.5	8.25	.280	52.	9.97	.192	73.	31.4
17	MC	125.	6.00	.040	200.	4.57	.023	60.	42.5
18	MC	80.	4.00	.050	100.	3.59	.036	25.	28.
19	MC	220.	5.50	.025	240.	4.27	.0178	9.	28.8
20	MD	37.5	16.06	.428	76.2	18.89	.248	103.2	41.8
21	MD	33.	10.75	.326	76.2	14.90	.195	131.	40.2
22	MD	72.	7.00	.097	138.	7.00	.051	92.	47.5
23	MC	75.	3.00	.040	180.	5.30	.0294	140.	26.5
24	MD	44.7	8.00	.179	74.8	8.00	.107	673.	40.2
27	MD	11.8	15.50	1.313	27.	23.96	.890	128.	32.2
28	MD	27.5	7.75	.282	42.6	9.09	.213	55.	24.4
29	MC	25.	5.00	.200	34.	3.51	.103	36.	48.4
30	MD	51.	11.00	.216	81.2	11.00	.135	59.2	37.5
31	MD	15.15	18.23	1.196	34.6	31.59	.913	129.1	30.9
32	MD	18.2	10.75	.592	33.3	15.47	.465	83.	21.4
33	MD	14.8	15.75	1.063	28.	22.78	.814	89.	23.4
35	MD	9.8	13.25	1.353	25.2	24.90	.988	157.3	27.
36	MD	12.2	12.25	1.004	31.	15.695	.506	154.1	48.6
37	MD	21.5	8.25	.384	46.6	11.42	.245	116.7	36.2
38	MD	44.9	8.00	.178	80.2	11.12	.139	78.5	21.9
39	MD	65.	7.75	.119	127.6	10.39	.081	96.3	31.9
40	MC	58.	3.00	.0518	90.	4.12	.0458	55.	16.
42	MD	13.	16.50	1.27	23.	16.50	.718	77.	43.5
43	MD	45.1	11.75	.26	54.	11.75	.217	19.9	19.8
44	MD	10.8	3.25	.301	25.6	4.63	.181	137.	40.
45	MC	50.	3.00	.060	151.	5.63	.0373	202.	37.8
46	MC	33.	4.50	.136	65.	5.93	.0913	97.	32.9
47	MC	70.	2.50	.0357	180.	3.79	.021	157.	41.2
48	MC	17.	3.00	.1765	32.	3.64	.1138	88.	35.5
49	MC	35.	2.00	.0572	73.	3.01	.0412	108.6	38.8
50	MC	49.	2.25	.046	90.	3.39	.0377	83.7	22.0
51	MC	34.	2.50	.0736	73.	3.87	.053	114.	28.
52	MC	73.	2.50	.0343	190.	3.64	.0186	160.	45.7
53	MC	75.	3.00	.04	550.	4.05	.0074	633.	81.5
54	MD	79.	11.25	.155	166.5	16.666	.10	110.7	35.4
55	MC	43.	5.25	.122	77.	7.37	.0958	79.1	38.2
56	MC	65.	1.39	.0214	325.	1.93	.0059	400.	72.5
57	MC	65.	1.39	.0214	360.	2.02	.0056	454.	73.9
60	MC	85.	1.39	.0164	316.	1.91	.006	272.	63.4
61	MC	160.	1.39	.008"	450.	2.51	.0058	181.	33.3

62	MC	120.	1.75	.0146	270.	2.33	.0086	125.	41.
63	MC	85.	1.00	.0118	190.	1.00	.0053	112.	55.
65	MC	220.	1.71	.0078	720.	3.01	.0042	227.	46.2
67	MC	150.	1.39	.0093	421.	1.78	.0042	180.	54.8
68	MC	180.	1.26	.007	447.	1.83	.0041	148.	41.5
69	MC	180.	1.26	.007	419.	1.83	.0047	133.	32.9
70	MC	125.	1.50	.012	151.	1.80	.0119	21.	0.
71	MC	108.	1.26	.0117	214.	1.98	.0093	98.	20.5
72	MC	24.	2.75	.1144	59.	4.02	.0682	145.	40.3
73	MC	23.	2.75	.1195	55.	4.14	.0753	139.	37.
74	MC	73.	2.50	.0343	140.	2.50	.0179	91.8	47.8
75	MC	190.	1.13	.0059	378.	1.49	.0039	99.	33.9
76	MC	220.	1.13	.0051	600.	2.21	.0037	173.	27.4
77	MC	220.	1.71	.0078	579.	2.43	.0042	163.	46.2
78	MC	41.	2.50	.061	99.	3.65	.0369	141.5	39.6
79	MC	60.	2.25	.0375	222.	4.62	.0208	270.	44.5
80	MC	35.	2.25	.0643	63.	2.97	.0472	80.	26.6
81	MC	75.	3.00	.04	172.	5.36	.0312	129.	22.
82	MC	42.	2.75	.0655	80.	4.07	.0509	90.	22.3
83	MC	400.	1.26	.0032	694.	1.67	.0024	73.5	25.
84	MC	23.	2.50	.1086	50.	4.35	.0871	117.	19.8
85	MC	23.	2.50	.1086	56.	4.18	.0748	143.5	31.1
86	MC	37.	5.50	.1485	81.	9.78	.1206	119.	18.8
87	MC	650.	1.26	.0019	1200.	1.83	.0015	84.6	21.
88	MD	88.	7.75	.0881	172.	10.25	.0596	104.6	32.4
89	MC	45.	2.75	.0612	68.	3.23	.0475	51.1	22.4
90	MC	25.	2.50	.10	37.	3.50	.0947	48.	5.3
91	MC	45.	3.00	.0666	127.	5.03	.0396	182.	40.5
92	MC	110.	1.39	.0126	210.	1.77	.0084	91.	33.3
93	MD	15.8	9.25	.585	23.1	9.25	.402	46.2	31.3
94	MC	190.	1.26	.0066	585.	2.42	.0041	208.	37.9
95	MD	18.2	10.75	.592	33.3	15.47	.465	83.	21.4
96	MC	180.	1.39	.0077	431.	1.85	.0043	139.5	44.2
97	MC	240.	1.50	.0063	492.	1.94	.0039	105.	38.1
101	MC	130.	1.75	.0135	278.	2.18	.0078	114.	42.2
102	MC	270.	1.00	.0037	509.	1.69	.0033	88.5	10.8
103	MC	35.	2.92	.0835	92.	3.85	.0418	163.	50.
104	MC	35.	3.24	.092	96.	4.984	.052	174.28	43.4
107	MC	82.	3.24	.039	187.	3.25	.017	128.	56.4
109	MC	55.	3.00	.0546	180.	3.93	.0218	227.	60.
110	MC	50.	3.00	.06	162.	3.72	.023	224.	61.7
111	MD	102.	7.75	.076	140.4	7.75	.055	36.6	27.6
112	MD	12.9	19.50	1.51	24.5	26.16	1.07	89.9	41.1
115	MD	45.3	7.25	.16	95.	10.35	.1089	109.	31.3
116	MD	33.33	13.71	.4113	65.37	13.07	.1997	90.3	51.4
117	MD	8.66	3.01	.347	16.	3.01	.188	86.	45.8
118	MD	90.	3.24	.036	316.	4.55	.014	251.1	61.1
119	MD	91.	12.04	.132	127.75	8.04	.063	40.3	52.2
120	MD	91.	11.26	.1237	162.	9.41	.058	78.	53.1
121	MD	242.	12.34	.0509	435.	9.35	.0214	79.7	58.
122	MC	160.	2.02	.0125	700.	4.73	.0067	337.	46.4
125	MD	67.	5.25	.0783	179.	12.91	.072	167.1	.007
126	MD	76.	5.25	.0667	209.	9.44	.0451	175.	32.2
127	MD	10.75	18.42	1.71	18.50	18.13	.98	72.1	42.7
128	MC	30.	3.25	.108	108.	4.45	.0412	260.	61.8
135	MD	9.25	17.22	1.86	32.	26.240	.82	246.	55.9
136	MD	14.	17.74	1.267	23.7	17.765	.749	69.3	40.7
137	MD	17.	15.71	.924	31.	18.06	.582	82.3	37.
138	MD	93.	11.55	.124	185.6	11.74	.063	99.5	49.2
139	MD	34.	14.81	.4355	43.	14.53	.3379	26.4	22.4
140	MD	74.	10.52	.1421	113.	9.33	.0825	52.7	41.9
141	MD	26.	11.97	.4603	70.	13.29	.1898	169.	58.7
142	MD	12.	12.25	1.02	32.	10.67	.333	166.6	67.3
145	CP, FI	11.	2.50	.227	25.	3.41	.136	127.2	40.
147	CP, FI	67.	3.35	.05	90.	3.04	.034	34.3	.32
148	MD	21.50	19.70	.916	48.8	23.68	.485	126.9	47.
149	MC	25.	2.47	.098	52.	3.765	.072	108.	26.5
150	CP, FI	18.	270.	.15	22.	2.99	.135	22.2	10.
152	MD	11.	13.52	1.22	31.	16.866	.544	191.	55.7
153	MD	144.	12.52	.087	158.5	7.56	.047	9.3	34.4

154	MD	8.	10.76	1.345	12.	12.74	1.061	50.	21.1
155	MC	80.	1.50	.0187	252.	1.88	.0074	215.	60.4
156	MC	80.	1.50	.0187	252.	1.88	.0074	215.	60.4
157	MC	261.	1.665	.0063	900.	2.765	.003	244.	52.3
158	MC	225.	1.40	.0062	432.	1.88	.0044	96.4	29.
159	SV	72.	6.30	.0875	82.	5.99	.075	13.9	16.6
160	SV	60.	5.25	.0875	80.	5.74	.0717	33.3	18.
162	MC	155.	1.65	.0106	615.	2.127	.0034	296.	68.
167	UD	40.	8.00	.20	61.	11.70	.191	52.5	4.5
168	MD	22.28	12.75	.5722	75.84	16.993	.224	240.	61.
169	MC	73.	1.75	.024	450.	2.442	.0054	516.	77.5
170	MC	144.	1.48	.0102	360.	2.025	.0056	136.	45.1
171	MD	18.3	3.24	.177	50.8	5.34	.105	177.5	40.67
172	MD	9.4	3.24	.344	30.5	4.24	.139	224.4	59.6
174	CP	12.	2.35	.196	20.	3.18	.159	66.6	18.8
175	CP	30.	2.35	.078	42.	2.80	.066	40.	15.4
176	MD	65.3	6.75	.103	155.	8.624	.055	137.3	46.6
178	MD	8.	15.84	2.26	22.8	26.82	1.176	185.	47.9
179	FI	45.	225.	.05	96.	2.607	.027	113.3	46.
181	MD	29.5	7.93	.268	82.8	11.60	.14	180.7	49.1
183	MC	36.	3.24	.09	45.	3.24	.072	25.	20.
184	MC	36.	3.00	.083	45.	3.00	.066	25.	20.5
186	MC	22.	2.88	.13	43.	3.493	.081	95.4	37.7
187	CP	17.	3.57	.21	29.	3.40	.117	70.5	44.2
190	MC	270.	1.53	.0057	787.	2.111	.0027	191.4	52.6
191	GR	150.	2.16	.0144	397.	2.80	.007	164.6	51.4
192	CP	17.	3.57	.21	26.	3.48	.134	52.9	36.1
194	CP	25.	2.34	.093	46.	3.38	.073	84.	21.5
195	CP	27.	2.34	.086	77.	3.34	.043	185.1	50.
196	MC	35.	3.00	.086	56.	3.575	.063	60.	26.7
197	MD	6.	3.25	.541	21.	4.17	.198	250.	51.2
198	KG	110.	2.34	.021	224.	2.86	.012	103.6	42.8
199	KG	90.	2.34	.026	153.	2.984	.019	70.	26.9
201	MD	11.5	17.50	1.521	17.	17.50	1.03	47.8	32.2
202	KG	85.	2.34	.027	167.	2.89	.017	96.4	37.
203	KG	75.	2.16	.028	144.	2.552	.018	92.	35.7
205	KG	40.	2.16	.054	95.	2.629	.027	137.5	50.
208	MC	56.	1.49	.0266	135.	2.24	.016	142.8	38.4
209	MC	360.	1.80	.005	2700.	3.654	.0013	650.	74.
210	MC	450.	1.44	.0032	2592.	3.132	.0012	476.	62.5
211	MC	225.	1.80	.008	603.	2.547	.0042	168.	47.5
212	MC	450.	1.44	.0032	1620.	2.46	.0015	260.	53.1
213	MC	450.	1.26	.0028	1200.	2.01	.0016	166.6	42.8
214	MC	270.	1.44	.0053	1260.	2.25	.0018	366.6	66.
215	MC	207.	1.75	.0084	1368.	2.668	.0019	560.8	18.6
219	MC	30.	3.06	.102	78.	4.994	.064	160.	35.8
225	CP	39.	2.34	.06	81.	2.89	.0357	107.7	40.5
226	CP	30.	2.34	.078	71.	3.536	.0498	136.6	36.1
227	MC	108.	1.80	.017	225.	2.463	.0109	108.3	35.9
228	MC	162.	1.80	.011	585.	2.895	.005	261.1	54.5
229	MC	225.	1.75	.0077	720.	2.80	.0039	220.	49.3
230	MC	162.	1.49	.0092	468.	2.645	.0057	188.8	38.
231	MC	350.	1.44	.0041	2700.	3.19	.0012	671.4	70.7
232	MC	350.	1.26	.0036	1986.	2.646	.0013	467.4	63.9
233	MC	335.	1.08	.0032	1350.	1.493	.0011	302.9	65.6
234	MD	17.	15.20	.894	34.	27.26	.802	100.	10.3
235	CP	43.	2.34	.0544	80.	2.857	.0357	86.04	34.4
236	MC	270.	1.80	.0066	702.	2.253	.0032	160.	51.5
237	MC	450.	1.62	.0036	1296.	2.154	.0017	188.	52.8
238	MC	162.	1.80	.011	450.	2.492	.0055	177.7	50.
240	MC	270.	1.53	.006	630.	25.5	.004	133.3	33.3
241	MD	55.	8.46	.154	126.	9.301	.076	129.1	50.6
242	MC	225.	1.44	.006	756.	1.974	.0026	236.	56.6
243	CP	72.	2.34	.032	144.	3.547	.0246	100.	23.1
244	MC	33.	5.58	.169	74.	6.430	.0869	124.2	48.5
245	MC	75.	2.52	.034	256.	3.12	.012	241.3	64.7
246	MD	8.	5.23	.654	26.	9.292	.3574	225.	45.3
247	MD	25.5	8.25	.324	40.	10.50	.2625	56.9	15.9
249	FI	60.	2.34	.039	98.	2.717	.0277	63.3	28.9
250	CP	55.	2.34	.043	76.	2.79	.0367	38.2	14.6

251	CP	39.	3.12	.080	65.	3.056	.047	40.	37.9
252	MC	270.	1.44	.005	720.	2.64	.0037	166.6	26.
253	MC	200.	2.70	.014	600.	4.20	.007	200.	50.
254	MC	315.	1.98	.006	780.	2.355	.003	147.6	50.
255	MC	315.	1.98	.006	1147.	2.527	.002	264.1	66.6
256	MC	270.	1.80	.007	1260.	3.244	.0026	366.6	52.3
258	MD	46.	9.08	.197	99.	11.33	.125	115.1	36.6
259	MD	21.	10.81	.515	51.	13.00	.255	142.8	50.5
260	MC	70.	2.52	.036	155.	3.135	.020	121.4	44.4
261	MD	40.	10.00	.250	72.	12.40	.172	80.	31.2
262	MD	47.	11.34	.241	101.	14.328	.1418	114.9	4[illegible]
264	MC	450.	1.98	.004	1053.	2.433	.0023	134.	42.5
265	MC	180.	1.80	.010	477.	2.393	.005	165.	50.
266	CP, FI	50.	2.34	.047	122.	3.370	.027	144.0	42.5
267	MC	35.	2.70	.077	85.	3.471	.041	142.8	46.7
268	MD	20.	17.91	.895	38.	23.448	.616	90.0	31.2
269	CP, FI	25.	2.34	.094	16.	3.29	.091	44.0	3.2
270	FI	36.	2.16	.060	48.	2.513	.052	33.3	13.3
271	MC	40.	2.52	063	99.	3.165	.032	147.5	49.3
272	MC	35.	2.88	.082	90.	3.656	.040	157.0	13.3
273	MC	42.	2.52	.060	90.	3.296	.037	114.3	38.3
274	MC	60.	2.52	.042	157.	3.324	.021	161.9	50.0
275	MC	135.	1.80	.013	262.	2.088	.008	93.9	38.4
276	MC	360.	1.53	.004	945.	1.875	.002	162.5	50.0
277	MC	360.	1.26	.003	756.	1.605	.002	110.0	33.3
278	MC	360.	1.53	.004	1260.	1.875	.0015	250.0	62.5
279	MC	315.	1.44	.005	1800.	2.190	.0012	472.0	76.0
283	MC	108.	2.52	.023	216.	3.231	.0149	100.0	35.2
284	MC	100.	3.25	.033	261.	4.149	.016	161.0	51.5
286	MC	360.	1.53	.004	1800.	2.055	.0011	400.0	72.5
287	MC	90.	2.75	.031	158.	3.396	.0214	75.5	30.9
291	CP	80.	2.34	.029	114.	2.855	.025	42.5	1.3
292	CP	40.	2.16	.054	72.	3.16	.044	80.0	18.5
293	MC	40.	2.88	.072	98.	3.814	.0388	145.0	46.1
*294	MC	45.	3.24	.072	122.	4.272	.0349	171.0	51.5
*295	MC	189.	1.26	.007	720.	1.649	.0023	281.0	67.1
296	CP	40.	2.16	.054	99.	3.010	.0304	147.5	43.7
297	KG	540.	2.16	.004	900.	2.685	.0029	66.7	27.5
299	MC	40.	2.88	.072	77.	3.805	.0495	92.5	31.2
300	MC	35.	3.24	.092	92.	4.352	.0473	163.0	48.5
301	MC	65.	2.52	.039	162.	3.381	.021	149.2	46.1
302	MD	16.	16.02	1.001	40.	17.691	.442	150.0	55.8
304	MC	30.	2.16	.072	61.	2.781	.0456	103.5	36.7
305	FI	40.	2.16	.054	99.	2.767	.0279	125.0	48.3
306	MD	45.	7.64	.170	100.	10.156	.1015	122.2	40.3
308	MC	40.	3.42	.085	70.	2.646	.0379	75.0	55.4
309	MC	135.	1.62	.012	450.	2.707	.0060	233.3	50.0
310	MD	25.	15.57	.623	51.	27.345	.536	104.0	13.9
311	MC	93.	3.00	.032	540.	2.718	.0050	483.0	84.3
312	FI	27.	2.25	.083	49.	2.623	.0576	81.4	30.6
313	MD	20.	13.42	.671	39.	21.045	.539	95.0	19.6
314	CP, FI	25.	2.52	.101	46.	3.253	.0705	84.0	25.8
315	CP, FI	25.	2.52	.101	36.	3.152	.0875	44.0	13.4
316	MC	180.	1.40	.008	305.	1.867	.0061	69.4	23.7
317	MC	108.	2.00	.019	270.	3.087	.0115	150.0	39.4
318	MC	180.	1.62	.009	630.	2.201	.0035	250.0	61.1
319	KG	300.	2.16	.007	476.	2.573	.0054	58.6	22.8
320	MC	70.	2.70	.0386	248.	3.504	.0141	254.1	63.5
321	CP, FI	175.	2.16	.0123	306.	2.631	.0085	74.8	30.8
323	CP, FI	60.	2.52	.0420	96.	3.236	.0338	60.0	19.5
324	MC	125.	2.34	.0187	540.	3.588	.0066	332.0	64.6
325	MC	90.	2.00	.0222	330.	3.462	.0105	266.8	52.7
326	MC	180.	1.53	.0085	720.	2.550	.0035	300.0	58.8
327	KG	100.	2.16	.0216	270.	2.910	.0107	170.0	50.4
328	MC	36.	2.52	.0700	144.	3.770	.0262	300.0	62.6
329	CP, FI	45.	2.52	.0560	72.	3.042	.0423	59.9	24.5
330	MC	360.	2.00	.0055	1200.	2.750	.0023	233.4	58.2
331	MC	135.	1.80	.0133	324.	2.357	.0073	140.0	45.1
332	MC	70.	2.52	.0360	180.	3.770	.0209	157.1	41.9
333	GR	180.	2.34	.0130	420.	2.685	.0064	133.2	50.8
334	CP	50.	2.16	.0432	96.	2.962	.0308	92.0	40.2
336	MC	36.	2.52	.0700	105.	3.266	.0312	191.9	55.4

XUM

337	MC	31.	3.25	.1048	58.	3.814	.0657	87.1	37.4
338	KG	225.	2.25	.0100	432.	2.622	.0061	92.0	39.0
339	MC	270.	1.80	.0066	1440.	2.460	.0017	433.0	74.3
340	MC	180.	1.44	.0080	1200.	2.487	.0021	567.0	73.7
341	KG	300.	2.16	.0072	828.	2.905	.0035	176.0	51.4
342	MC	315.	1.44	.0046	1350.	1.853	.0014	328.	69.5
343	KG	300.	2.16	.0072	531.	2.622	.0049	77.0	45.8
344	MC	225.	1.80	.0080	738.	2.213	.0029	228.0	63.8
345	MC	540.	1.44	.0027	2160.	2.190	.0010	300.0	63.0
347	MC	315.	1.80	.0057	900.	2.437	.0027	185.7	52.6
348	KG	250.	2.16	.0086	612.	2.784	.0045	144.9	47.7
349	MC	225.	1.80	.008	1440.	2.820	.0019	540.0	76.3
350	MC	225.	1.40	.0062	347.	1.753	.0051	54.2	17.7
351	MD	23.	16.38	.712	37.	21.058	.5691	60.8	20.0
352	MC	675.	1.44	.0021	3600.	2.187	.0006	434.0	71.3
353	MC	540.	1.44	.0025	2160.	1.917	.0008	300.0	68.0
354	MC	540.	1.62	.003	2592.	2.964	.0011	379.9	63.3
356	MD	22.	13.68	.621	45.	17.665	.392	104.5	36.8
357	MC	900.	1.44	.0016	2025.	2.106	.0010	125.0	37.5
359	MC	540.	1.80	.0033	1800.	2.550	.0014	233.5	57.5
360	MC	270.	1.80	.0067	1512.	2.145	.0014	461.0	79.1
361	MC	540.	1.80	.0033	1900.	2.250	.0011	251.8	66.6
362	MC	2700.	1.44	.0005	7650.	1.793	.0002	183.4	60.0
365	MC	630.	1.44	.0023	1512.	1.785	.0012	140.1	47.8
366	MC	108.	1.62	.015	540.	2.504	.0046	139.4	69.4
367	MC	1800.	1.44	.0008	4320.	2.133	.0005	140.0	37.5
369	MC	540.	1.98	.0035	1440.	2.460	.0017	166.9	51.5
370	MC	3600.	1.44	.0004	7560.	1.782	.00023	110.0	42.5
373	MC	675.	1.08	.0016	2160.	1.557	.00072	220.0	55.0
374	MC	360.	1.08	.0030	900.	1.605	.0018	150.0	40.0
375	MD	40.	2.75	.0688	241.	3.663	.0153	502.5	77.7
376	MC	360.	1.44	.0040	990.	1.830	.0019	175.0	52.5
377	MC	540.	1.44	.0027	1640.	1.865	.0011	203.7	59.3
378	MC	900.	1.62	.0018	1548.	1.988	.0013	71.9	27.8
379	MC	450.	1.62	.0036	4500.	2.367	.0005	900.0	86.0
380	MC	1350.	1.62	.0012	2520.	2.142	.0008	86.8	33.3
381	MC	1350.	1.62	.0012	2520.	2.142	.0008	86.6	33.3
382	MC	900.	1.80	.0020	2160.	2.277	.0011	140.0	45.0
383	MC	900.	1.80	.0020	2520.	2.317	.0009	180.1	55.0
384	MC	900.	1.44	.0016	3060.	2.205	.0007	240.1	56.3
385	MC	900.	1.44	.0016	4140.	2.259	.0005	360.0	68.8
386	MC	1350.	1.62	.0012	4500.	2.367	.0005	233.2	58.4
387	MC	630.	1.44	.0023	2016.	1.845	.0009	220.0	60.8
388	MC	225.	1.44	.0064	711.	1.816	.0026	216.0	59.3
389	MC	540.	1.44	.0027	1440.	2.100	.0014	166.9	48.1
390	MC	360.	1.80	.0050	1260.	2.460	.0019	250.0	62.0
391	MC	360.	1.44	.0040	1296.	2.136	.0016	260.1	60.0
392	MC	180.	1.44	.0080	630.	1.864	.0029	250.0	63.8
393	MC	900.	1.44	.0016	3780.	1.782	.0004	320.0	74.9
394	MC	900.	1.62	.0018	2160.	2.097	.0009	139.9	50.0
396	MC	2250.	1.62	.0007	6300.	2.117	.0003	180.0	57.2
397	MC	58.	5.51	.095	80.	4.08	.051	38.9	56.8
398	MD	37.5	16.06	.326	76.2	14.900	.195	131.	40.2
400	MC	360.	1.98	.0055	900.	2.393	.0026	150.0	52.8
401	MC	540.	1.62	.003	1800.	2.145	.00101	233.3	66.3
402	MC	1800.	1.62	.0009	5400.	2.37	.0004	200.0	55.5
403	MC	900.	1.26	.0014	2475.	1.768	.0007	175.0	50.0
404	MC	900.	1.26	.0014	2700.	2.01	.0007	200.0	50.0
406	KO	180.	2.25	.0125	432.	2.928	.00677	140.0	45.8
407	CP	31.	2.16	.0697	75.	2.984	.0398	141.9	42.9
408	MC	70.	2.88	.0411	180.	4.13	.02294	157.1	44.1
410	MC	70.	2.70	.0386	162.	3.895	.0240	131.4	37.8
411	MC	75.	2.70	.036	252.	3.800	.0151	236.0	58.0
412	CP	25.	2.34	.0936	48.	3.268	.0681	92.0	27.2
413	KG	300.	2.16	.0072	675.	2.91	.0043	125.0	40.3
414	KG	300.	2.16	.0072	720.	3.18	.0044	140.	38.9
415	MC	225.	1.62	.0072	600.	2.52	.0042	166.6	41.6
416	MC	162.	1.80	.0111	675.	2.718	.004	316.6	63.9
417	MC	540.	1.26	.0023	2475.	1.899	.0008	358.3	65.2
418	MC	450.	1.98	.0044	975.	2.355	.0024	116.6	45.4
419	MC	315.	1.44	.0046	1350.	2.021	.0015	328.5	67.3
420	MC	1350.	1.44	.0011	5400.	1.993	.0004	300.0	63.6
421	MC	27.	3.42	.1266	63.	4.121	.0654	133.3	48.3

423	MC	60.	2.34	.039	135.	3.45	.0255	125.	34.6
424	MC	900.	1.62	.0018	1683.	2.37	.0014	87.	22.2
425	MD	22.28	12.75	.5722	75.84	16.993	.224	240.	61.
427	MC	360.	1.95	.0055	1620.	2.807	.0017	350.0	69.0
428	MC	270.	1.62	.006	720.	2.19	.003	166.6	50.0
429	MC	675.	1.98	.0029	3600.	3.08	.0009	433.3	69.
430	MC	162.	1.80	.0111	450.	2.325	.0052	177.7	53.1
431	MC	540.	1.26	.0023	3375.	2.169	.0006	525.	73.9
432	MC	1350.	1.44	.0011	4050.	1.854	.0004	200.	63.6
433	MC	360.	1.44	.004	1350.	2.19	.0016	275.	60.0
435	MC	450.	1.26	.0028	1350.	1.673	.0012	200.	57.2
436	MD	23.	10.81	.47	72.	13.410	.1862	212.1	60.3
437	MC	450.	1.62	.0036	990.	2.010	.0020	120.	44.4
438	MC	360.	1.44	.004	990.	1.954	.0020	175.	50.
439	MC	225.	1.62	.0072	450.	2.033	.0045	100.	37.5
440	MC	225.	1.80	.008	540.	2.550	.0047	140.0	41.2
441	MC	450.	1.98	.0044	900.	2.505	.0028	100.0	36.3
444	MC	75.	3.24	.0432	180.	4.86	.027	140.	37.5
445	MC	75.	1.80	.024	216.	2.682	.0124	188.	48.3
446	MC	450.	1.44	.0032	1242.	2.082	.0017	176.	46.8
447	MC	360.	1.62	.0045	810.	2.235	.0028	125.	37.7
448	MD	21.5	8.25	.384	46.6	11.42	.245	116.7	36.2
462	MC	450.	1.98	.0044	2160.	2.73	.0013	380.	70.4
463	MC	1080.	1.80	.0017	3240.	2.169	.0007	200.0	57.0
465	MC	450.	1.44	.0032	1620.	1.853	.0011	260.0	65.6
467	CP	50.	2.25	.045	75.	2.95	.0393	50.0	12.7
468	MC	54.	3.06	.0567	162.	4.083	.0246	200.0	56.6
469	MC	50.	3.24	.0648	120.	4.739	.0394	140.0	39.2
471	MD	16.	20.79	1.2994	27.	22.484	.8327	68.7	35.9
472	MC	35.	2.88	.0823	72.	3.68	.0511	105.7	37.9
473	MC	450.	1.44	.0032	972.	1.934	.0019	116.	40.6
474	MC	30.	2.16	.072	60.	2.757	.0459	100.	36.2
476	MC	1080.	1.62	.0015	2097.	1.958	.0009	94.1	40.0
479	KO	140.	2.16	.014	400.	2.943	.0072	185.7	30.0
480	KO	500.	2.16	.0043	1800.	2.889	.0016	260.	62.7
481	KO	300.	2.16	.0072	765.	2.71	.0035	155.0	51.4
487	MD	14.	3.60	.2571	24.	4.72	.1966	71.4	23.5
488	MD	16.	3.51	.2193	33.	4.997	.1511	106.3	30.6
490	MD	50.	3.24	.0648	84.	4.237	.0504	68.	22.2
492	MC	72.	3.24	.045	198.	4.098	.0207	175.	54.0
493	MC	79.	2.88	.0364	198.	4.263	.0215	150.	40.9
494	MC	54.	3.24	.06	85.	4.319	.0507	57.4	15.5
495	MC	175.	3.24	.0185	350.	4.062	.0116	100.	37.3
497	MC	120.	3.24	.027	540.	4.825	.0089	350.	67.
498	MC	125.	3.24	.0258	450.	4.395	.0097	260.	62.3
502	MD	54.	10.08	.1866	115.	14.224	.1236	113.9	33.7
505	MC	250.	1.80	.0072	792.	2.287	.0028	216.8	61.1
506	MC	315.	1.26	.003	1080.	1.74	.0016	242.8	46.6
507	CP	70.	2.16	.0308	180.	3.013	.016	157.1	47.7
508	CP	70.	2.16	.0308	193.	2.91	.015	175.5	51.2
509	IT	36.	2.52	.07	54.	2.992	.0554	50.	20.8
512	CP, FI	30.	2.25	.075	90.	3.207	.0356	200.0	52.5
513	CP, FI	54.	2.16	.04	150.	3.40	.0226	177.7	43.5
514	MD	8.	3.60	.45	25.	4.387	.1752	212.5	61.
515	MD	9.25	17.22	1.86	32.	26.24	.82	246.	55.9
516	MC	270.	1.44	.0053	1260.	2.25	.0018	366.6	66.
517	MC	450.	1.44	.0032	1620.	2.46	.0015	260.	53.1
518	MC	225.	1.40	.0062	432.	1.88	.0044	96.4	29.
519	MC	80.	1.50	.0187	252.	1.88	.0074	215.	60.4
520	MC	80.	1.50	.0187	252.	1.88	.0074	215.	60.4
522	MC	22.	2.88	.13	43.	3.493	.081	95.4	37.7
523	MC	2400.	1.62	.0007	9531.	2.37	.0002	297.	70.1
524	MC	400.	1.40	.0035	774.	1.768	.0022	93.5	37.1
525	MC	375.	1.62	.0043	630.	1.965	.0031	68.0	27.9
526	MC	1900.	1.62	.0008	7200.	2.37	.0003	278.9	62.5
527	MD	9.4	3.24	.344	39.	4.614	.1183	314.8	65.6
528	MC	500.	1.62	.0032	1800.	2.145	.0012	260.	62.5
529	MC	500.	1.44	.0028	2340.	2.302	.001	368.	64.3
530	CP, FI	11.	2.50	.227	25.	3.41	.136	127.2	40.
531	KG	90.	2.34	.026	153.	2.984	.019	70.0	26.9
		91125.62		.01846		2168.853		206.8	
			1682.71		279656.63		.00775		58.

322. The average saving in cost of production, production increase and increase in the average wages is as follows:

323.

	Percent
Production increase	206.8
Cost reduction	58.0
Wage increase	28.9

324. There is, of course, a certain amount of added overhead in connection with the type of organization described above. The percentage of increase is small, however, compared to the net saving in total cost of turning out a given product. In the last analysis the question is—what saving in total cost can be realized by the adoption of scientific management? The writer's experience justified him in placing this figure at 25 per cent to 35 per cent. These are figures which he has realized in practice and are not based on guess work.

APPENDIX

19—Organization Record

325. The organization record should be started at the very commencement of the organizing engineer's work with a client. Without this record his work cannot be complete. No reorganization work is complete and well done unless it is self-sustaining and perpetuates itself after it loses the guiding hand of the organizing engineer, who brought it into being,—hence, the organization record.

326. The organization record consists of a complete and properly indexed set of instructions covering the duties of every member of the organization except the rank and file. The planning room records control the details of all shop operations. This is done through the medium of the subjects covered in detail above in the main part of this article.

327. The organization record enables each incumbent to thoroughly understand not only his own responsibilities, but also the relation of his particular work to that of the rest of the

organization. Each person is enabled to familiarize himself with the duties of those above him. This tends to more quickly fit a person for advancement. When promotion finally comes he is enabled to definitely assume all the responsibilities of his new work. Without a complete organization record all of the original scope and detail incident to each position cannot be positively assured as time goes on and new men assume various duties.

328. Much of the detail and knowledge of the business routine in the average organization is solely in the hands of

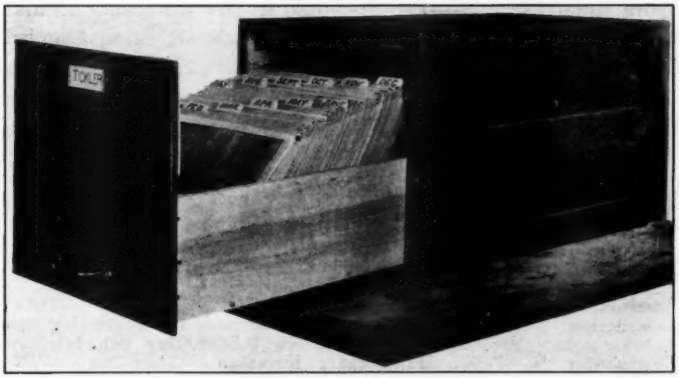

FIG. 20—TICKLER FILE
Paragraph 331

the various individuals employed. This condition is of course unfavorable to the highest efficiency and should not exist. The owners and management should be in possession of all the detail of the business. They should not be dependent on the collective knowledge of all their employes. Unless the management does absolutely control all details of a business, they are not in a position to get maximum results at a minimum cost.

329. As first stated, the organization record puts the record and control of an organization where it belongs. It also assures the stability of the structures as a whole. It also

always assures a final and definite placement of responsibility. It eliminates "pull" and partiality. It helps everyone to stand on his own feet and co-ordinates the various individuals into an enthusiastic, harmonious and efficient whole—a real organization.

330. Although the organization record does not vary in principle, it is more complex in some lines of business than in others. In a plant of any size the instructions will number between one and two hundred. Following is a partial list of the instructions contained in the organization record of the Detroit Plant of The Aluminum Castings Company. The more important instructions are listed to give the reader an idea of the subjects covered. The same methods are being installed in the company's other plants.

331. The partial list of instructions referred to in paragraph 330 is as follows:

Instruction	I	Organization Record
Instruction	II	Employment Agent
Instruction	III	Identification Check
Instruction	IV	Shop Rules
Instruction	V	Department Symbols
Instruction	VI	Day and Night Watchman
Instruction	VII	Shop Time Clerks Job Time Cards
Instruction	VIII	Timekeeper
Instruction	IX	Factory Mail Service
Instruction	X	Timekeeper's Instructions Pertaining to Change to the 9-hour Day Schedule
Instruction	XI	Maintenance Foreman
Instruction	XII	Cost System (Preliminary Instructions to Cost and Production Clerks)
Instruction	XIII	Time Study Foreman
Instruction	XIV	Chief Chemist
Instruction	XV	Standard Rates & Bonus Classes
Instruction	XVI	Man Day Computation
Instruction	XVII	Pound Cost Chart
Instruction	XVIII	"Safety First"—Safety Appliances
Instruction	XIX	Foremen's Bonus (Attention of Time Study Foreman)
Instruction	XX	Overtime Wages
Instruction	XXI	Route Clerk
Instruction	XXII	Order of Work Clerk
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Instruction	XXIV	Repair Tag Form FAP120
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Instruction	XXXI	Care of A. B. Co. Indirect Heating System
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Instruction	XLVIII	Asst. Cashier.
Instruction	XLIX	Production Clerk
Instruction	L	Asst. Production Clerk
Instruction	LI	Stores Clerk
Instruction	LII	Move Material Foreman
Instruction	LIII	Chief Inspector
Instruction	LIV	Core Superintendent
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Instruction	LVII	Asst. Mold Superintendent
Instruction	LVIII	1Q—Sand Mixing Foreman
Instruction	LIX	1C to 6C Core Room Foreman
Instruction	LX	1F—Furnace Room Foreman
Instruction	LXI	1M—Molding Room Foreman (Class A—Light Alum)
Instruction	LXII	2M to 4M Aluminum Molding Room Foreman (Class C—Heavy Alum)
Instruction	LXIII	1H—Heat, Light & Power Equipment Foreman
Instruction	LXIV	1I—Inspection Department Foreman
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Instruction	LXVI	1N—Knockout Department Foreman
Instruction	LXVII	1P—Pattern Department Foreman
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Instruction	LXIX	1R—Receiving Clerk
Instruction	LXX	1D, 1G & 1S Shipping Clerk (Delivery & Garage Department)
Instruction	LXXI	1T-2T Trimming Department
Instruction	LXXII	1U—Machine Shop
Instruction	LXXIII	1V—Forge Shop
Instruction	LXXIV	X—Storekeeper Store Room
Instruction	LXXV	1Y—Yard Department
Instruction	LXXVI	1W—Welding Department
Instruction	LXXVII	Local Costs
Instruction	LXXVIII	Local Plant Weekly Cost Report
Instruction	LXXIX	Care of Office Heating System
Instruction	LXXX	Inspection Committee
Instruction	LXXXI	5M—Brass Molding Foreman
Instruction	LXXXII	Time Clock Card Numbers
Instruction	LXXXIII	Sand Blast

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Instruction	LXXXIV	Daily Defective Casting Report
Instruction	LXXXV	Routine of Cleveland Plant
Instruction	LXXXVI	Brass Finishing Dept. 2U Detroit
Instruction	LXXXVII	Danger Signs & Accident Prevention
Instruction	LXXXVIII	Bonus Pay Slips
Instruction	LXXXIX	Selling Prices of Castings & Method of Estimating Costs
Instruction	XC	Pouring Gang & Pouring Temperatures—Alum
Instruction	XCI	Standard Flask Sizes for Bench & Squeezer Work
Instruction	XCII	Standard Job Classification for Bench, Tub and all Squeezer Work
Instruction	XCIII	Rough Stock Bushings (98 metal)
Instruction	XCIV	Operation of Sand Mixing Machinery
Instruction	XCV	Metal Stock Room
Instruction	XCVI	Weight Clerk
Instruction	XCVII	Purchasing
Instruction	XCVIII	"Lynux" Melting Practice & Bonus

332. In the following sections of this appendix will be found copies of four of the above instructions. These are reprinted in full to indicate the manner in which this part of the work is handled.

20—Route Clerk, Instruction XXI

333. All orders for the shop are to be handled through the planning room by the Route Clerk. All work of whatever nature for customers is to be ordered and approved through the sales department and issued to the planning room in the form of a general order, form FAP113 (for castings), and miscellaneous general order, form FAP121, for work other than castings. Castings order symbols cover three groups—A, B and C. Miscellaneous orders belong in the M group. In the event that the *employe* wants work done by the shop, the same kind of a general order should be made out and the work routed to the proper departments in the same way as for any other customer. General orders are to be issued in duplicate; one copy for the planning room and one for the shipping room files.

334. A cost sheet is to be opened for each general order as soon as it is received in the planning room. The method of distribution of costs is covered in the Cost Clerk's instructions **(XII)**. This Instruction is referred to here as the Route Clerk

must understand the method of determining costs so that he can more intelligently distribute and route work to the shops.

335. The work for plant, or what we call property account, should be built on miscellaneous general orders, form FAP121 ("P" series) and otherwise handled the same as above explained, as far as cost sheets, etc., are concerned.

336. On receipt of a general order, the Route Clerk shall analyze same and issue the proper orders to the shop. These are known as work orders, form FAP104. The order must be analyzed so as to determine exactly what part of the work is to be done by the several departments necessary to fill the other. This analysis will be indicated in some cases by the specifications of the other; in other cases, the Route Clerk will have to consult with the Production Clerk or others, such as the Superintendents, the Core and Mold Superintendents, or the Pattern Shop Foreman. It may be necessary at times to take the matter up with the Factory Board on special new work, or when there is a question as to which department it should properly be routed to.

337. In filling out these work orders, fill them out in duplicate and complete as indicated by the printing thereon. The work orders are numbered in an unbroken sequence from 1 to 99999, and then repeat. There are two methods of checking the time spent in the shop against the live work orders; one of these is from a list with the work numbers listed in numerical order. As each work order is made out, the job or order number to which such work applies (see paragraph 4) should be placed on the list opposite the work order number. At the same time the routing as provided for on the back of the general order or miscellaneous general order form, as the case may be, should be filled in. Attention to these two details is extremely important for the following reasons:

338. After an order has been issued and the work routed and we wish to know the condition of that order, we first look at the general order or the miscellaneous general order form in the order book. The routing on the back of the order tells us at once what work has been routed to the shop and where. The planning board tells us whether that work is in process or

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not. The face of the general order tells us what shipments have been made to date. The daily schedule and job tally sheet tells us what our schedule is daily. The process chart gives us the history of the processes in the shop. These items cannot be so traced from our planning room record if the Route Clerk omits to fill out the routing on the order form.

339. When the work orders are complete and returned to the planning room as referred to below in paragraph 352, the work number on the list above referred to should be crossed off. This prevents any possibility of time being charged in the shop on job time cards against work numbers which have been completed and further shows the reason for issuing all work to the shop on individual work order numbers. All the time reported must be checked against the work order number list to determine on what job or order number the time is to be charged, as well as to be sure that the work order number is still active. This transportation of time takes place before the Cost Clerk's distribution of the time to the cost sheets. Obviously if the work number shown on the job time card is crossed off of the work number list, it shows an incorrect entry, which must be corrected before posting to the cost sheet.

340. The routing on practically all of our work involves the making of castings. The departments chiefly involved as a general proposition are the pattern shop, carpenter shop, forge shop, flask department, core rooms, mold rooms, knockout, trimming room, inspection room and shipping room. As an attempt has been made to generally classify all the kinds of work being done in the various units, it is not particularly difficult to determine the *departmental* routing on most of our castings business. To determine the *individual locations* in the core room and mold rooms to which individual parts of the work should be routed, involves more careful consideration. This is to be handled as follows:

341. The Pattern Clerk will turn into the planning room a record as per the following, covering the core boxes received with each set of patterns or equipment. This record is in addition to the pattern record, form FAP108. This record is

to be typed on a 3 x 5-inch card, known as the "standard core routing record," form FAP121.

NORTHWAY CRANK CASE 18023-1, 6-20-13
TOTAL BOXES—9

CB	Name of Core.	Cores per Casting.	Routing.
1	Body	1	4C21
2	Body	1	4C21
3	Body	1	4C21
4	Housing	1	4C11
5	Geor Case	1	4C21
6	Large Gear Side Core.....	1	1C11
7	Mag. bracket	1	1C11
8	Small brg. side core.....	1	1C11
9	Arm core	1	1C21

342. By referring to the above example, attention is called to the fact that we will consider the benches or locations in the core rooms at which cores are to be made by grades—

Benches 1 to 10 inclusive—Grade One
Benches 11 to 20 inclusive—Grade Two
Benches 21 to 30 inclusive—Grade Three

The idea is that the Route Clerk should distribute work orders to the various core departments, specifying one of the benches available in the grade in which that class of core belongs. By referring to the above sample, it will be seen that the first three items show a routing 4C21. This indicates that the cores should be made in 4C and at one of the benches in the 21 to 30 grade. In other words, the help employed at this group of benches is considered best qualified to make that kind of cores.

343. In the future when issuing work orders to the various core departments, a separate work order must be made out for each individual core box belonging to a pattern, following the standard routing as above explained. Obviously, there will be considerable choice as to which one of the benches from 21 to 30 the order should be routed. This question is answered by a study of the planning board in conference with the Order of Work Clerk and the Schedule Clerk. Consultation with them will show that certain benches in the 4C21 group are already well supplied with work. This will also be indicated by the planning board. Work should be routed to a bench

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having the least work ahead and on which the daily requirements will permit of running the number required per day on the work under consideration. Again, it may be necessary to route to a bench in the 4C21 group which is at the time idle. This involves, of course, putting on additional help unless some other job is running out, making some help available, or which can be run part of the time and still get sufficient production from all the boxes.

344. It is necessary in getting down to real scientific planning, to fill out all of the information called for on the next work order, particularly the number of men required. The Schedule Clerk in preparing his departmental daily schedule and job tally sheet in consultation with the time study men and the Route Clerk, will be able to report each day as to the number of men actually required (according to our standard data) to turn out the production slated for that day. This matter of allotment of help will be taken up more completely later on after these preliminary arrangements are working. I want to get the shop men, particularly the Foreman, and Time Clerks, familiar with this new method before holding them down too close on the number of men.

345. The question of standard routing for cores has been mentioned at some length because it involves the most complicated part of our work. It is not unusual to have castings requiring 25 or 30 cores. This obviously involves much more work in routing, planning and following up than all of the other operations put together.

346. Little need be said regarding the method of handling the next work orders to the pattern and mold rooms and other departments involved in the turning out of the castings, after the cores are ready.

347. The idea is to be explicit and whatever reference may be necessary should be put on the order, particularly in regard to pattern shop work. The work order should also show the date at which the work is to be completed. The Route Clerk gets this information by consulting with the Order of Work Clerk and Schedule Clerk. In all cases, however, the nominal routing as indicated by the instructions for the Move Material

Foreman; i. e. "Move to" should be carried out complete *and always, of course, by symbol.* It is *not* sufficient to mark on the order "Move to 4M" or "3C" or "1P", the symbol should be completed by the bench or floor number, as "4M20", "3C15" or "1P10."

348. The Route Clerk is responsible for the operation of the planning board in the planning room. Through the Time Clerks in the shop departments, he must see that their planning boards are kept in exact accordance with the planning room board.

349. The above applies particularly to showing by the red signal cards all floors or benches in all departments not operating. It also pertains to having the board always correct in so far as the work orders in process in the shop daily, are concerned, and their proper distribution on the pegs to departments, benches, floors, etc. These work orders, of course, are to be on the top pair of pegs. The red signals on the planning board should be set the first thing each morning and the Shop Time Clerks must see that their department boards are identical with the Route Clerk's board in the planning room. This board must be watched throughout the day and if a job is shut down, starts up, or a floor or bench becomes active, the planning boards should all be changed to correspond.

350. The work orders on the bottom pair of pegs indicate that the material or equipment is not ready at that location so that the work order does not become active. The Route Clerk is to report daily on the daily plant report, form FAP132, the number of floors and the percentage of the total floors of each department that is operating that day.

351. In the case of the core rooms, knockout, trimming, inspection and shipping rooms and perhaps the bench molders, making chills, etc., in the mold rooms, there may be more than one work order on a pair of pegs for any one floor or bench. The fact that the top pair of pegs shows, say—five work orders, indicates that each of those work orders runs a short time each day. To what extent they run is controlled through the medium of the daily schedule and job tally sheet which is issued by the Schedule Clerk. In all other cases, however,

there should be but one work order on the top pair of pegs; that work order being the one representing the job which is actually being worked on at that time. Other work, such as that carried on by the maintenance gang, would be covered by standing orders, or by work orders covering specific jobs. In cases of the pattern, carpenter and forge shops, but one order should be visible on the top pegs at a time. As soon as the work called for by the said work order is completed, it should be signed up by the Department Foreman and passed to the Move Material Foreman, who will move the material to the destination specified and promptly forward the work order to the planning room.

352. On receipt of the completed work order in the planning room, the corresponding work order on the planning room board must be removed and the top order on the bottom pair of pegs moved up to take its place. This operation has likewise already been done by the Department Foreman in the shop and the succeeding job already gotten under way. The prime object of the factory mail service is to take care of these inter-department work orders. The schedule of fifteen minutes is practically fast enough to keep the planning room within thirty minutes' touch with the shop. There may be cases, however, where the Material Foreman may be delayed in moving work built from one location to another. In each case of this kind, he should take a memorandum of its destination and pass the work order along promptly to the planning room.

353. It is important that the Route Clerk make his work orders for specific operations wherever possible, rather than cover a job in a general way. In other words, the entire scheme is one to guarantee absolutely the operation of the shop along a clearly defined schedule and only on such work as we wish to have processed. As a cost proposition, it is also important that the work be analysed into as many operations or elements as possible. By this method we can control not only its production, but also when it is to be made, as well as how long it should take. In only a few instances will standing orders be issued and they will be chiefly for work done by the maintenance department, and for which a certain number of men will be allotted to keep such work up to date.

354. After the Route Clerk has routed his orders as above explained, he is responsible for the automatic changing of the planning board due to the completion of jobs in the shop (see paragraph 352.) The regulation of this board as far as the order of work is concerned is up to the Order of Work Clerk. He also manipulates the work orders on the board in so far as their arrangement as to sequence, etc., is concerned. In other words, the Route Clerk is responsible to see that the shop is supplied with orders and that his planning room and shop boards agree with actual shop conditions throughout the day. He is not responsible, however, for the order in which the work is done. This is up to the Order of Work Clerk entirely.

21—Schedule Clerk, Instruction XXIII

355. The Schedule Clerk is assistant to the Order of Work Clerk. His chief duty is to see that the schedules and other records referred to below are kept up to date. He shall work with the Order of Work Clerk in planning and recording the schedules of operations to be performed. As explained below, he will follow up the details after the work in the shop has once started. He shall familiarize himself with Instruction XXIII, covering the duties of the Order of Work Clerk whose position he fills during the latter's absence.

356. The first schedule is what is known as the "process schedule." This is a graphical record kept on Schedule form FAP124, showing the chief operations on all unfilled orders on our books. The schedule is made out from the general order at the time it reaches the planning room. All of the different operations necessary to fill the order are to be listed. The red line indicating the scheduled date of processing is ruled in opposite each operation to correspond with this date as indicated across the top of the sheet. On this process schedule all red ruling indicates what has been planned for the future or which has not been done, and black lines indicate a record of past performance.

357. The Schedule Clerk as the Order of Work Clerk's assistant is to keep up this process schedule. Each day a narrow horizontal black line is to be ruled in the proper date

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column opposite the operations on every job which was running that day. This work should be done in the morning at the time the Route Clerk checks up his red signals on the planning board. The narrow line is continued from day to day until the operations are complete. On such days as the operation is not running, of course, the line shows a break. When the operation is finally completed, the last day which it ran shall be ruled in with a heavy black line corresponding in width to the heavy red line as ruled indicating the promised schedule. This method gives us a graphical schedule which forms a history of the days the operation was in process, as well as the date on which it was completed.

358. In listing orders on the process schedule for castings, the following departmental or operation symbols are to apply to each of such orders; namely, 1P, 1K, MC, MD and IT. These symbols should be listed in the order named. For orders other than castings, it will only be necessary to list such operation or department symbols as may be necessary on that particular order. The listing for castings above mentioned represents our standard routine which all castings have to pass through. It is true that in some cases castings may be without cores, but the standard listing should be adhered to because it is possible that it may be found desirable to ram up cores or change the design to get economical production. On general principles, it is better to have rather too much space allotted to each order than not to have enough to insert subsequent operations.

359. Referring above to paragraph 357, the Schedule Clerk must keep in close touch with all changes on the planning board throughout the day. It is not sufficient to check over the process schedule every morning and rule off these jobs which are running early in the day; other jobs may be started up, in which case the process schedule should show that they are under way. The result is that the scheduling is a rather continuous routine operation.

360. Though the Schedule Clerk is directly responsible for the care of the process schedule and the issuance of the daily schedule and job tally sheets (form FAP115), his responsibility regarding these two chief divisions of his work require that he

keep in close touch with the Route Clerk and the Order of Work Clerk. In fact, the detail of the work of these three men is so closely connected that it is practically impossible for one to work out the detail of his work during the day independent of the others. This applies to practically all three. It is extremely imporant in connection with scientific planning not to overlook the above statement, as each one of these three men is responsible for information and routine which is necessary to the other two.

Daily Schedule and Job Tally

361. Instruction XXI explains the method of issuing work orders to the shops; each work order, however, indicates the total amount of work to be done. For example, if we are making one thousand crank cases and there are twenty cores to each case, there would be issued a work order on each of the twenty core boxes for the total number of cores required from it for one thousand cases. These would be distributed to the different benches in the core rooms. This order cannot, however, indicate how many of these cores from each core box should be made each day or when to start production in this department. The same is true to a certain extent of the mold rooms, but there is not the detail and complication in following up the molding operations that there is in following so many different cores.

362. To control the shop methods after the work orders are issued, it is necessary to issue to the Foreman of each department daily schedules of what he is to turn out for the succeeding day. This daily schedule will be used by him on the succeeding day, not only as his order for the day's work, but by the Time Clerks on which to record the tally of the work as it is done during the day for each different item.

363. In some cases it will be desirable to issue the daily schedule and job tally sheet more than one day ahead. This is particularly true on new production jobs under bonus, where it is desirable to get at least two days' run of the cores before starting to mold. In planning out the items on each department daily schedule and job tally form, the sheet for the next day's

work must be delivered to the Foreman not later than three o'clock in the afternoon on each day. In general the cores on the core department daily schedules are to be used on the day after they are made, except in such cases as above mentioned where it is desirable to have them made up at least two days ahead. This statement applies particularly to such jobs where it is economical to make only one or two days' supply and not to such jobs as small cores, where three or four hours' run would make up several weeks' supply. In such cases, judgment in planning must be exercised so as to take care of small jobs with as little starting and stopping of the core boxes as possible, but considering also the liability of breaking cores if stored too long. This, of course, applies to intricate cores rather than to small print cores, etc. The latter can be made up some time ahead and there is not much danger from loss or breakage.

364. In cases where cores are only made up one or two days ahead, care must be exercised in ordering only the required quantity plus a reasonable allowance for breakage. In other words, if a coremaker can in three hours make sufficient cores for a day from one box, there is obviously no object in his running the box all day. It is the regulation of this quantity and a clear understanding of the molding room requirements that will have such a direct bearing on our core cost, as well as on the ability of the planning room to deliver cores to the molding rooms in ample time.

365. The issuance of the daily schedule and job tally to the molding rooms is a comparatively simple matter. The quantity of castings required each day can in the majority of cases be closely estimated; in such cases, of course, the quantity which appears on the job tally represents the number of molds, as the loss cannot be pre-determined exactly.

366. For the present at least, the knockout will not be provided with a daily schedule and job tally, as the work is handled more as a definite bulk to be taken care of daily and which depends entirely on the production of the mold rooms.

367. The trimming room daily schedule and job tally will be issued exactly as above explained for the core and mold rooms. The quantities called for on this tally, however, are to agree with the maximum quantity which we call for on the sheets issued to the molding rooms. In other words, the product which we sell first appears in salable form in the mold rooms; the knockout takes care of the mold rooms' daily production and the trimming room must do likewise, otherwise we will run into congestion in this department which will begin to tie up production.

368. The same thing applies to the daily schedule and job tally issued to the soldering and welding department. Although this tally sheet will not be issued to them daily at present, it will be eventually.

369. We come now to the schedule issued to the shipping room and the solderers and gasoline testers. These two daily schedules and job tallies should be identical unless perhaps when the previous day's production from the solderers and gasoline testers exceeded the shipping schedule, in which case the shipping schedule would include these castings, plus those which are listed on the schedule for the gasoline testers and solderers. The sand blast room, of course, is in the same relation to the testers and solderers as the knockout is to the mold rooms. As the sand blast will not have a daily schedule in written form, they will be required, of course, to keep up the production of the gasoline testers and solderers, sand blasting being the last operation prior to shipping.

370. In the case of the daily schedule sent to the Shipping Clerk, there is no tally to be kept opposite the itemized list. We are simply utilizing the same form that is utilized in the other cases, however, the Time Clerks of the various departments are to use the forms during the day and record the amount of work processed, delivering them promptly at quitting time at night to the Schedule Clerk in the planning room.

371. It is obvious that the Schedule Clerk must be very careful in working out the list of detailed parts on the various daily schedules and job tally sheets so that shortages may be provided for, as well as to prevent overstocking on certain

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parts to the delay of others. This is particularly important on cores, although an equally serious congestion might occur in the trimming and soldering departments. In all of this planning the Schedule Clerk and the Order of Work Clerk must work together.

372. The general planning done by the Order of Work Clerk is of course insufficient to get results in the shop. These general plans must be gone over by him and the Schedule Clerk and the subdivision of the work involved in the shop must be carefully listed on the tally sheets as above explained. Later a schedule sheet will be provided (form FAP124) on which to record in cumulative style all data pertaining to the daily production of cores from each different box. A similar record showing castings production is already in existence in the Production Clerk's charge (production card, form FAP102). The same record must of course eventually be kept for cores, otherwise we will have no check on the breakage or actual consumption. This record, however, will be taken up later as an addition to this instruction.

22—Order of Work, Clerk, Instruction XXII

373. The Order of Work Clerk is responsible for the other in which work passes through the shops, as well as to see that operations are brought through according to our process schedule and the various daily schedules and job tally sheets. The maintenance of delivery schedules is also up to the Order of Work Clerk. To schedule work, it is important, first, that each order be given a completion date. This date may not be on the order when it reaches the planning room from its original source. If there is a data on the order, it must be checked over and approved by the Superintendent or altered to suit conditions. If the date has to be changed, the change must be taken up with the customer and a date finally determined and the customer notified; in the event that this date is not satisfactory to the customer, he will come back offering an opportunity for adjustment. It must be realized that the date of completion is absolutely essential as otherwise no scheduling whatever can be done. If we cannot determine when the order

is to be filled, there is obviously no use in starting production. It would be dangerous to attempt to work on an order on which a date could not be determined as the customer might be liable to cancel, or for lack of O. K., etc.

374. Having determined the shipping date, the next step is to plan the sequence of operations as arranged for when the completion date on the order was arrived at. It is from this schedule of dates that the Route Clerk determines the dates which he puts on his next work order as explained in his instruction (XXI).

375. In determining dates and arranging schedules for deliveries, the Order of Work Clerk as a member of the Factory Board should take up at the daily Board meetings, all important matters pertaining to uncompleted orders. Very often a conference is necessary to determine a schedule of completion dates for certain parts of the work. It is up to the Order of Work Clerk to see that these schedules, whatever they may be, are lived up to. In checking over the work daily in the shops, those castings or other parts not coming to schedule for that or future day's shipment, (or schedule) must be forcibly followed up either through the Foreman or Superintendent as the case may be. In other words, we must schedule our work intelligently and not let anything that we can control interfere with realizing our schedule.

376. The work on schedule should be planned out at least two days ahead. This will be further explained in Instruction XXIII covering the duties of the Schedule Clerk, but this scheduling is described here somewhat as the Schedule Clerk is responsible to the Order of Work Clerk. It is not sufficient to check up shipments or operations when they are due: it must be done *before,* so as to anticipate or remove obstacles or adjust interferences, etc.

377. Through the Schedule Clerk the Order of Work Clerk must maintain a record (subject to revision from time to time) showing the quantities of each different casting promised for shipment daily. It is obvious that the information going to make up this list must be obtained from **several sources, but**

chiefly from our daily production schedule and our process schedule, all of which are worked out to agree with promises shown on the general orders.

378. In Instruction XXIII the method of issuing the daily schedule and job tally to the various departments, including the shipping room, has been referred to. All departmental schedules must have continuous attention, including of course, the shipping schedule. If these schedules are not maintained, then of course the entire sequence of operations is broken up, shipments are delayed and our planning and processing efficiency falls off.

379. Eventually, all promises of delivery and completion of all shop alterations will be put up to the Order of Work Clerk. He is in effect a functional foreman and in conjunction with the Route Clerk practically controls the sequence and completion of operations in the shops. In connection with their planning, they will invariably have to consult with the Time Study Foreman so as to determine how much time allowance to make in planning the sequence of the various operations.

380. The Order of Work Clerk will have to use his judgment in arranging dates with the Schedule Clerk for both work in process and future work not yet started. He is not limited as to the source from which he gets the desired information. Very often it can be obtained from the planning room records. In other cases, he will have to consult some of the department heads. In important cases, it would be well in any event to check over what dates are planned at the Factory Board meeting so that the Superintendent and others present can understand thoroughly just what schedule he has arranged for. Obviously, the important thing is to make our schedule as short as possible and at the same time one that we can live up to. It may be well to mention here that it would be well to have the process and departmental schedules call for more daily production than does your shipping schedule. By doing this, you will take care of loss and unforeseen delays in processing, leaving a margin to insure the net number of castings promised to customers daily.

381. In following through our daily schedule, it is not sufficient that the work be superficially checked over. Work must

be followed continuously and the fact that it is not being worked on will not be an excuse for not getting it shipped. The Order of Work Clerk, Schedule Clerk and Route Clerk are really the three men to whom the Superintendent looks to carry out our various schedules. In the event that from any cause these schedules are not being adhered to, this fact should be repeatedly reported to the proper authorities until such time as the required action is being taken. There will, of course, be emergency cases beyond our control where we will be forced to miss our schedule. In all other cases, however, if the Order of Work Clerk reports in time, the responsibility is up to the Superintendent and not to the Order of Work Clerk.

382. If the Order of Work Clerk has carried out the above instruction and the Superintendent, after being notified, cannot get the work through the shop, the matter is then out of the hands of the Order of Work Clerk. In such cases, the Superintendent must report back to the Order of Work Clerk so that such delayed items may be removed from, or suspended on, the daily schedule. In such cases the customer should be notified.

383. As explained in Instruction XXI, the Route Clerk is responsible for the planning board as far as its condition and accuracy in representing the actual shop condition is concerned. The Order of Work Clerk, however, is the one responsible for the order in which the work orders on the planning board are arranged. In other words, if a bench or floor has a certain amount of work allotted to it, the order in which this work is to be done is indicated by the order in which the work orders are arranged on the pegs. This order or arrangement is not to be changed by the Route Clerk, only by the Order of Work Clerk or his assistant, the Schedule Clerk; the latter, of course, only doing this on orders from the Order of Work Clerk. The Order of Work Clerk is also responsible for the order of the work orders on the shop planning boards. In other words, one of his duties is to arrange the sequence of operations, as well as the sequence in which the same operations from one bench or floor are to come. He does this primarily on the planning room board, but he must also see that the shop board is changed to agree with it. The shop boards must always be in

exact agreement with the planning room board. This is the real arrangement of order of work which after all, is the Order of Work Clerk's chief duty. The Route Clerk's routine and the Schedule Clerk's routine, however, are the two essential preliminaries necessary to assure accurate planning.

23—Inspection Committee, Instruction LXXX

384. To get the best results from our Shop and Service Inspection Department, it is desirable that the general scheme of inspection be handled along the following lines. This instruction is written to govern the general handling of inspection methods entirely separate from the instructions applying to regular inspection.

385. Superintendent, Chief Inspector and Service Inspector will be governed by the following:

386.

a—Standards will be established from time to time on various work; these will include either drawings, references, written data or gages, as the case may be. These standards are to be determined and mutually agreed upon between ourselves and our customers. Customer's requirements, of course, must be consistent with best foundry practice and the commercial production of their product.

387.

b—Our product is to be produced in accordance with the above mentioned standards applying to each specific piece. These standards are to be adhered to, it being understood that we have already, as specified in Paragraph 386 accepted them and agreed to work in accordance with the same.

388.

c—In case of an unusual condition or a question as to the interpretation as to what standard has been established, or in case of a question as to whether a piece actually meets with the standard or not, such case shall be referred to the Inspection Committee. This Inspection Committee is to consist of the Service Inspector, who, on account of his duties, will be thoroughly familiar with the customer's requirements; the Superintendent, who is the man responsible for the product; and the Chief Inspector, who is the man being directly responsible for the shop inspection.

389.

d—The Chief Inspector's work is to be final on all matters of inspection, except in cases above referred to. No such case shall be settled definitely by either the

Superintendent or the Service Inspector, but must always be settled in accordance with the majority vote with the three being present. In other words, our Chief Inspector is to be up-held in his decisions and ordinary routine inspection is not to be passed up to the Inspection Committee for settlement.

390. The method described above is to further the mutual interests of our customers and ourselves. The three men representing the Inspection Committee are the ones chiefly involved in the matter of quality. Their close co-operation will eventually result in keeping our standard of quality at the highest possible mark.

391. The General Superintendent may be called in, in an ex-officio capacity, on matters which the majority of the Inspection Committee desire to have him personally investigate.

Discussion

MR. J. W. COLLINS:—As I am not familiar with many of the details of Mr. Parkhurst's paper I am not in a wholly favorable position to discuss it. However, I might say that in connection with his work at our plant he has worked out a standard production table for bench and squeezer work, that is proving very satisfactory. A few remarks on this may, therefore, be of interest. The data from which the table (similar to Table II, page 224) was compiled were gathered by two time-study men, each working in a different plant and comprised several thousand observations; about six or eight weeks were consumed in the time-study work. Every operation in making a mold was timed and recorded, such as putting the flask on the follow board, riddling enough sand on the pattern to cover it, filling the drag with heap sand, etc. The time necessary to set one, two or a dozen cores in a mold was also taken.

With this information at hand, it was then a question of allowing a certain amount of time for a certain size mold, figuring its cubical contents, and allowing a certain amount of time to set cores at so much time per core. There is an allowance

made for ramming different kinds and shapes of patterns and the jobs are classed as plain, irregular and complicated. I think the job classes are fully explained and tabulated in the paper. We use this table almost entirely in putting bench work on bonus and find that it checks very closely with actual time studies we have taken on jobs after they have been running in production.

For the benefit of those who are unfamiliar with time-study methods, I wish to say that a time-study man who is thoroughly acquainted with molding operations is placed on the molding floor and times each operation with a stop watch. He usually spends one or two days on the job, or until he is satisfied he has a fair average time on each operation. Before starting to time the job, everything is placed in readiness with machines working in first class shape and plenty of cores on hand, no time being allowed for hold-ups of any kind. However, if a job is held up for any reason after it is placed on bonus, the men are allowed the time they are detained.

When the average time necessary to make the complete mold is decided this time is divided into the number of working hours in the day and this gives the maximum production. If 80 per cent of this figure is reached the men commence to drawn bonus and as the production increases over the 80 per cent the bonus increases. The men are paid on hourly rate and the bonus is in addition to this, which when added to their pay for a day really increases their hourly rate. I might also add that the men are paid a bonus of 25 per cent of their pay while time studies are being taken on their job. When a job is once put on bonus the price is never changed unless the method of making it is changed, or different equipment used. If a job is made more difficult to mold through change of design we re-time it and then change the bonus, and if it is made easier to mold we sometimes leave the bonus stand unless the change is too great. We have been working under the bonus system for over two years now and we have seen some wonderful results.

Considerable difficulty was experienced in the beginning in getting the men to take hold and try to make bonus even with 60 per cent as the minimum, this being the figure we started with. In four or five months we had several gangs that would

work together and make the bonus, so that the next jobs we put on were started at 70 per cent, and now all jobs are started at 80 per cent. The old 60 per cent and 70 per cent bonus jobs still remain unchanged, although they run very seldom now on account of being old and out-of-date automobile parts.

At the present time, everyone in the plant from the men who unload the sand and the metal into the plant to the chippers and inspectors, are familiar with the time-study and bonus system and are perfectly satisfied with it. In fact, men who happen to be working on new work on which no bonus has been set, ask to be put on bonus jobs so they can work faster and earn more money. I might also add that the money earned as bonus is paid to the men in a separate envelope, so they can readily see the amount earned over their regular hourly pay. I do not know of anything further I can say unless that I may be able to answer a few questions.

MR. WILLIAM JENKS:—May I ask this question: If the job is one where a man has to put up 100 molds before he can get any bonus, assuming the wages to be $3.50 a day, for the next ten molds, how much bonus would he receive?

MR. J. W. COLLINS:—In the first place it would depend on the class he was in, as each class of help is separated. For instance, a laborer's maximum bonus is 25c and is class No. 1; the molder in this case might be in, say class No. 5, and his maximum bonus would be $1.25. Now suppose he made 100 molds and this was the 80 per cent mark, he would get probably 70 or 80 cents when he reached the 100 mark. Then if he made 10 more molds he would make around 30 cents more.

THE CHAIRMAN, MR. ALFRED E. HOWELL:—I would like to ask Mr. Mueller, of the Mueller Mfg. Co., Decatur, Ill., if he will discuss this question a moment?

MR. H. MUELLER:—We work on the bonus plan, paying the same proportion as the regular day's wage. I don't think that is right, although we are working on it and I guess we have spent $500,000 in the entire factory in systematizing, and we are still at it. We are trying the plan of giving an extra cash benefit for any suggestions that will

increase our production; we might give $100 for a 100 per cent increase.

We want to try to avoid making any changes after a cost or price is once established, because as soon as you make a change once you might as well stop. The men will not produce as much as they can if rates are continually tampered with.

MR. F. A. SCHULTZ:—I probably could explain our bonus system a little better than Mr. Mueller, because I am right in the foundry and it is under my charge. We have been running the system about 12 years. We haven't got it perfect, that is, so that every job takes care of itself. We have classified the work as near as we can but there are some jobs, of course, that are a little stiffer than others. The men put up a certain number of molds for a day's work, and receive a bonus on the excess production. The men are classified according to ability and experience. Now, if a man has put up 100 molds a day and he puts up 150, he just makes half as much again as his regular day's pay. We don't pay the men their money every pay day with their other regular check. We did this at the start, but found it was bad practice, so we hold the bonus money for three months. That is, we pay it every three months, and then it becomes a sum instead of being mere spending money. This encourages the men to make good use of it. Our men each draw from $20 to $150 bonus every three months. You can readily see that the amount that we specify for a day's work is not too much for any man to do; but it is a fact that when we first started into the proposition, it was a hard job to get the men to take it up.

When I first started on the bonus proposition, I took a job and brought it to a man and told him I expected him to put up 50 molds in a day. He looked at me and smiled. I said, "I mean it."

He said, "I'd like to see the color of the guy's hair that could do it."

I said, "All right, just give me your apron."—I took his apron, put it on, and by three o'clock that afternoon I had the 50 molds up. The man stood by and watched me do it.

The next day I brought him over another job which was no harder or no easier than the one we had made the day before.

I said, "Red,"—he happened to have red hair—"don't you think you could do that?"

He said, "By God, I could try."

Well, he did it. About four o'clock that day he had his job up and he did a good job, too. After that I had no real trouble, and the men soon saw that if they put up more work, they got more money.

I can't understand why the bonus system should be put on a sliding scale. If you can afford to pay a certain amount for a mold for your regular day, I can't see why you couldn't afford to pay it for any extra work. Most of the molders that we have today working in foundries are not very intelligent men; they can't figure up a sliding scale. There are a lot of men who come to me and want me to figure up their bonus. They think it isn't right. We take it up and figure it over and find that it is right. Where you would be in a sliding scale proposition it's hard to say.

Revision of American Foundrymen's Association Standard Cost System

Introduction to Cost Accounting

By HARRINGTON EMERSON, New York.

Cost accounting is in reality exceedingly simple. The object of cost accounting is to find out when, where and for what you spend your money. This is not of very much value unless you know how much you ought to have spent.

To know what standard expenses ought to be, to know what actual expenses were—this is the whole object, aim and use of cost keeping.

If every time you pay out money you look closely at the amount, know what it is for, and that it is neither too much nor too little, you have in reality a perfect cost accounting system. The whole object of any cost accounting system is to enable you to do this more easily.

Costs are a part of the necessary records of a business.

A record is very different from a report. A record is a statement of fact. A report is a statement of opinion. All records should have the following qualities.

Truthfulness;
Promptness;
Sufficiency;
Simplicity;
Classification; and perhaps
Permanence.

If a cost record lacks any of these qualities, it is not a good record. Many cost systems are reports, not records.

Truthfulness is the essential quality. If that is lacking the whole system is no good.

Promptness comes next. We want to know what our expenses are before we incur them, if possible; which means that we must have standards. Even if we do not know what our expenses are before we incur them, we want to know what they are before we pay them. Afterward it is too late.

In order to know our costs promptly, our system must be sufficient and simple; and it helps simplicity and sufficiency to classify the costs.

Bookkeeping makes the record permanent.

Classification

A cashier, in counting money, likes to keep the gold and silver and copper separate from the paper money. This is his first classification.

Next he separates the gold from the silver, and the silver from the nickels and coppers. He next puts the bills of each value in separate piles and the coins in separate piles. Then, and not before, does he begin to count what he has on hand or what he pays out. Even if you hand in to him $26.87 he grabs the big bills first.

One twenty dollar bill	$20.00
One five dollar bill	5.00
Three half dollars	1.50
Three dimes	30
One nickel	05
Two copper cents	02
Total	$26.87

He has classified first and counted as he classified.

We must also first classify all expenditures. There are three and only three absolutely distinct classes of expenditures.

Material expenses;
Personal payments (wages, salaries, fees);
Capital charges.

Keep these three classes entirely separate.

Never permit in the same bill both materials and personal payments. Do not allow any bill to read "For iron, cartage, and unloading, $87.00." It must read—

Five tons pig iron at $16.00 equals	$80.00
Cartage	6.00
Unloading	1.00
Total	$87.00

When it reads this way you can see right away whether $16 per ton is too much, whether $6.00 is too much for hauling,

whether $0.20 a ton for unloading is four times as much as it ought to be.

Capital charges are a little more complicated. A separate account is always to be kept of money invested in the business. This investment is not an operating expense, but the expenditures necessary to maintain the capital are operating expenses. These expenses are only four in kind,

Taxes,
Insurance,
Obsolescence and Depreciation,
Interest.

A very elementary system of accounting would be

Total Capital Investment.....		$100,000
Capital Charges		
Taxes	$ 1,000	
Insurance	800	
Obsolescence	5,000	
Interest	6,000	
Total capital charges.....		$12,800
Total Materials		
Pig iron, 1,200 tons at $16 equals....	$19,200	
Coke, 200 tons at $5 equals.....	1,000	
Sand, 1,000 tons at $1 equals.....	1,000	
Total materials.....		$21,000
Wages and Salaries		
Salaries	$16,000	
Wages	48,000	
Fees	1,800	
Total personal payments.....		$65,800
Total expenditures.....		$99,600

Costing per pound $0.0422 for 2,360,000 lbs. good castings.

There are all the elements of a good cost system here, but we can improve on it.

It is very desirable to distinguish between what are called direct and indirect expenses. A direct expense is one that can be charged directly to the product as iron, or coke, or cores, or sand, or molding labor or cleaning labor. Indirect expenses as power or maintenance or supervision or rent cannot be directly charged to product. It is very desirable

to know what expenses for materials, for persons and for capital charges are direct and what indirect.

It is, however, a widespread error and delusion that indirect expenses should come down in comparison to direct expenses.

All expenses should be as low as they can be made, yet have good operation. An absolute as well as a relative increase of indirect expenses may be the cause of better operation. If we can secure at double the salary a superintendent who cuts iron losses to 5 per cent, who melts 10 tons per ton of coke, who lowers molding and cleaning expenses, indirect expenses for his salary rise, but costs go down per pound.

It is not hard to keep direct expenses and indirect expenses separate. A simple way of keeping perfect elementary accounts is to enter each item on a separate little sheet or card of paper.

We have four different colors each in two shades—

White for capital investment.
Blue:—
    Dark for direct capital charges;
    Light for indirect capital charges.
Yellow:—
    Dark for direct materials;
    Light for indirect materials.
Red:—
    Dark for direct labor;
    Light for indirect labor.

Put all the white cards together, both debits and credits, and you have the total capital investment, which must at any moment correspond with inventory.

Put all blue cards together and you have total charges.

Put all yellow cards together and you have total materials.

Put all red cards together and you have total personal bills.

Sort your dark blues, dark yellows, dark reds together and you have total direct costs.

Sort your light blues, light yellows and light reds together and you have total indirect costs.

XUM

Sort the light cards to the four indirect accounts—

Power,
Maintenance,
Supervision,
Rent.

and you have classified all your direct expenses. This will help you to find out whether per horsepower-hour or per pound of product you are paying too much for power, whether for amount of equipment or per pound of product you are paying too much for maintenance, whether per pound of product or number of men employed you are paying too much for supervision, whether per pound of product or floor space occupied you are paying too much for rent.

Anybody who can learn to play any card game, who has enough intelligence to know the difference between clubs and diamonds, between a king and a jack, knows enough to keep fundamentally correct, elementary accounts.

The more complicated chart presented by Mr. Mason is merely a development of the same system.

Foundry Cost Analysis

By J. K. Mason, New York.

Conspicuous in the galaxy of modern foundry needs, there stands out an all prevailing one which in itself becomes probably the weakest element in the operation of making castings—the need for clear cut, immediate and accurate information as to the cost of parts produced. In an industrial period so clear visioned and scientific, such a condition is the more to be regretted in that it suffers still further by comparison with the vastly improved shop methods which have come to the industry. Any consideration of ways and means of bettering the situation becomes of vital worth when men realize that cost information carries the foundry

to eminent success or to utter failure as that information is good or poor.

The only explanation that can cover the present lack of good cost figures, is the bonanza-like condition of industrial growth during the last half century. Our industrial fathers have been blessed with an abundance of material and labor, and profits have come with reasonable consistency. The country has witnessed a period of extensive economic expansion. Now, however, it has reached the turning point when all who would live must profit from the smaller things—must eliminate the little wastes in time, material and energy by a science that can come only from correct and sufficient knowledge of costs.

Four Natural Divisions

In presenting to you the accompanying chart, a few words are necessary in explanation. Foundry costs divide themselves into four natural parts:

1.—The cost of iron before it is melted.
2.—The cost involved in converting it into a molten state.
3.—The cost entailed in the preparation of molds, of cores and in the pouring of metal; and
4.—The cost of cleaning and inspecting the output.

Such costs are cumulative. That is, as one pound of metal passes through the successive operations, its value appreciates step by step by reason of the newer and newer expenses that are laid upon it during its course of change from raw iron to finished casting.

Over in New England they make immense snowballs by rolling little ones over and over till enough layers of snow have adhered to make the size desired. The result is a cumulative one. In just this manner the initial raw metal cost may be conceived of as the germ or core, to which adhere the successive wrappings of operative costs which go to make up the total.

Net Cost of Raw Metal

Beginning, then, with the raw metal, the analysis chart establishes a separate cost division comprised of costs for pig iron; home scrap; foreign (or purchased) scrap: and

remelt (gates, sprues and floor scrap). From the total must be deducted whatever bad castings and remelt is returned. The resulting cost is that of the iron charged in the cupolas for the period covered by the figure.

In the proper sense, all metal handled comes from or returns to the stores department. It makes no difference what may be the size or organization of the foundry. Its material is stored; and though its storage space may merely be one end of the main floor, yet storage expense is present. Consequently charges or credits for metal taken or returned must be established at rates which include storage expense.

If you will examine the section of the chart entitled "Stores Department" you will see that metal costs start with the invoiced price. By deducting discounts and adding freight and demurrage charges, you have what is termed a direct cost of material.

There comes now the stores burden. It is comprised of the expenses for clerical help, office supplies, truckers and so forth occasioned by the stores department in its work, plus an overhead charge proportioned as will be explained hereafter under the title "Overhead Expense."

Direct cost of material plus this stores (or material) burden results in a gross cost of materials and supplies from which is established the charge per pound for iron and per unit for all supplies, taken day by day for foundry operation. All of which means, as just stated, that daily or weekly charges for iron and supplies must include not only the first price paid, but an additional charge to include a proportion of storage expense and overhead. Thus is determined Net Cost of Raw Material.

Cost of Conversion

There comes now the consideration of conversion costs and their structure. The chart so clearly outlines the details of conversion costs that there is little need for explanation. Suffice it to say that there are three chief elements:

(a) labor and foremanship;
(b) materials, and
(c) overhead.

These comprise the entire expense involved in reducing the iron to a state capable of pouring into the molds. When added to the Net Cost of Raw Materials the result delivered is the Cost in Ladle, as shown.

Cost of Floor

Floor costs are the most complex of any involved in foundry work. Owing to the fact that cores and sand must be subjected to preliminary treatment before being available for use on the floor, floor costs must be divided into three sections, namely

Core room,
Sand room, and
Molding room.

Core room and sand room costs must be assembled separately from all others and distributed to cores and sand produced before these materials can be charged against molding expenses. It might be questioned whether the operation of determining these preliminary costs is justified by conditions. Eminently it is. For cores and sand must be prepared in advance of the time when they are used by the molders; and, further, oftentimes both the core room and sand room turn out in a given period far more cores or sand than needed during the same period for molds made. Therefore preliminary costs must be distributed individually to cores and to cubic yards of sand through separate records giving the individual outputs of those rooms.

Core room and sand room costs must, therefore, be segregated from all other costs. As cores and sand are drawn by the molders, proper charges must be made for each core taken, and for sand at a proper cost per cubic yard.

Floor costs proper are divided here into three general heads, namely

(a)—Direct floor cost,
(b)—Supplemental floor cost and
(c)—Floor overhead.

The last named does not include core room overhead; that being allotted to core room in a direct figure and

brought to floor through the charges for cores used. Sand room is not charged with overhead because of its relatively small importance. Such overhead as might be proportioned there, is divided between core room and molding floor. Its entire expense is finally borne by cores through the core sand mixed, and by molds through the facing sand consumed in them. Green sand used on the floor is, of course, charged directly against floor expense as used.

Thus is floor cost prepared for combination with cost in ladle. The cumulative result delivers the Cost in Cleaning Room; and here the analysis may pass to the question of cleaning costs.

Cost of Cleaning

Cleaning is a more or less simple consideration from the viewpoint of general costs. Its difficulties come with the act of distribution to individual castings. For the present, however, it may be stated that in cleaning, as in conversion and floor, three general heads comprise the entire figure. They are

(a)—Direct cleaning cost,
(b)—Supplemental cleaning cost, and
(c)—Cleaning overhead.

And when added to the Cost in Cleaning Room just mentioned, the preparation of gross cost figures is complete in the term "Gross Cost of Finished Castings."

The Costs Per Pound

Now arises the proposition of determining costs per pound, both for gross output and for individual parts or symbols. The first is easy. From the records of output of good castings a gross poundage figure is determined, which, when applied successively to net raw metal cost, conversion cost, floor cost, cleaning cost, cost in ladle, cost in cleaning room and gross cost of finished castings, establishes the respective costs for each pound of gross good output.

Why Consider Only Good Castings?

Questions may be asked why only good castings are considered in all pound cost figures. Response is almost to

be made in a Yankee answer. From what sort of output do you realize profits, good castings or both good and bad? Obviously only the good product is available for use or sale. Now, during the progress of the metal throughout the four divisions cited, certain work is expended upon certain castings which, in the final inspection, are suitable only as scrap for re-charging in the cupola. Work so expended costs money. But the cost of it can in no way be returned and melted over with the iron. Scrap iron ordinarily is of such mixture of iron, steel and alloys that even its raw value may fall below that of pig iron. The scrap value may be returned; but the value of work expended must be diverted to the iron which comes out in a form available for use or sale. Therefore, good castings must bear the burden. As greater skill is given to properly melting, molding, coremaking, etc., fewer bad and more good castings result. Proportionate costs per pound will then fall by reason of the presence of more good castings to bear the cost and of fewer bad castings to cause wasted effort. If ten men make ten castings and five of them are bad, the five good castings must bear the whole burden of cost, except such small sum as is taken back to stores in the scrap value of the five bad castings. This is the inevitable result of waste and inefficiency, and is one of the strongest of arguments against the cheap and unskilled employe. Nothing but saleable results can bear the burden of cost.

Let this point be illustrated. Suppose a day's records show

9,000 lbs. pig iron @ 0.01 equals	$ 90.00
1,000 lbs. scrap @ 0.0075 equals	7.50
Labor	50.00
Overhead	27.50
Materials	50.00
Total costs	**$225.00**

At the finish of inspection, records show

	Lbs.
Gates, sprues and floor scrap	1,000
Bad castings	9,000
Good castings	0
Total	**10,000**

The result is an expense of $225.00 with no salable return.

Suppose now that the next day's results show a total cost of $225.00 with an output of

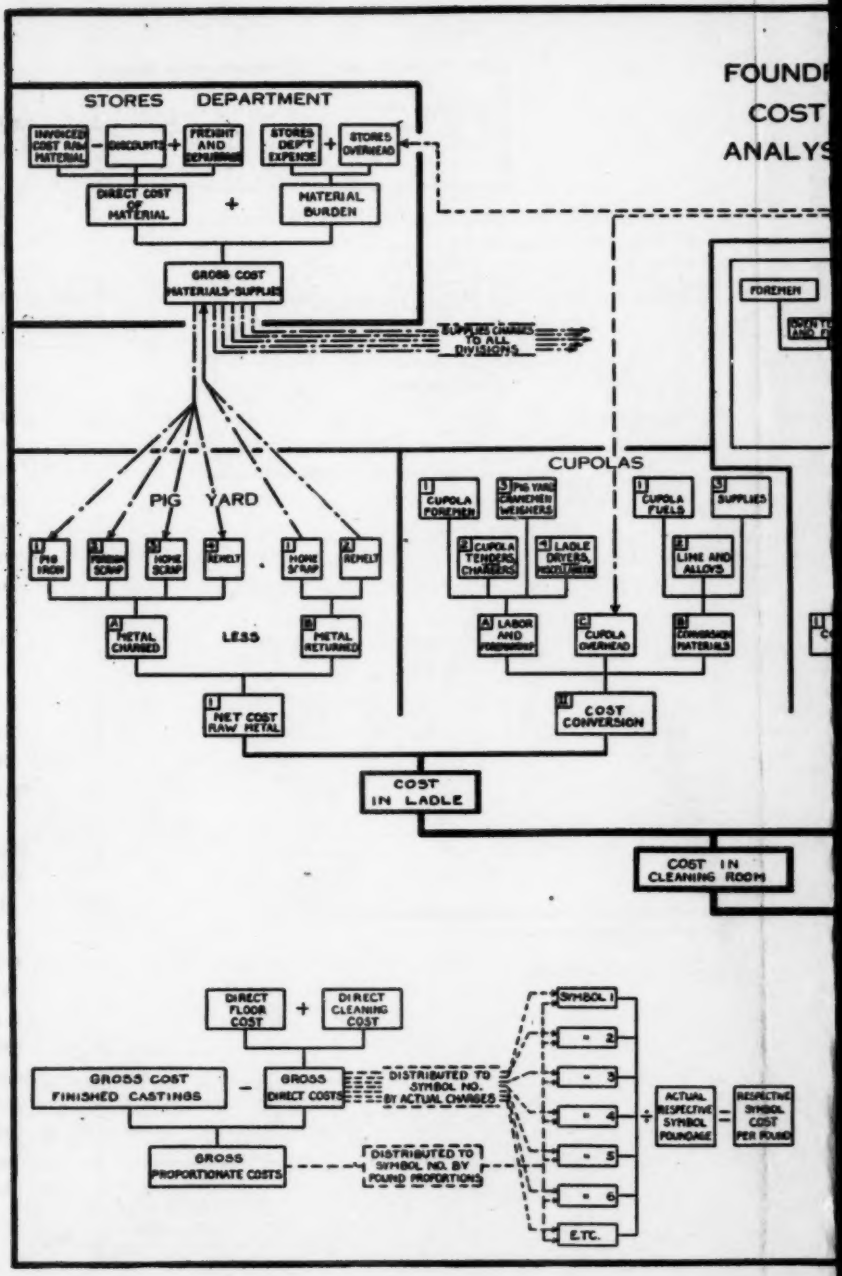
	Lbs.
Gates, sprues and floor scrap	1,500
Bad castings	3,500
Good castings	5,000
Total	10,000

On the latter day costs would equal $225.00 less scrap value for 5,000 pounds of remellt and bad castings at, say, $0.75 per hundred pounds, $37.50; leaving $187.50 to charge against the 5,000 pounds good output. This would mean a pound cost of $0.0375. But wait! What shall be done with the previous day's costs? There was an expense of $225.00 which may be reduced by the return to stores of 10,000 pounds of scrap at $0.75 per hundred, $75.00, a net debit of $150.00. This must be cared for, and when added to the expense of the second day, brings the latter total up to $337.50. Divide this figure by the 5,000 pounds of good output which was the only achievement of the two days' effort expended, and pound cost jumps from $0.0375 to $0.0675. Where would be the result if those castings had been sold for $0.06? A total loss of $37.50 or 12.5 per cent of the sales income.

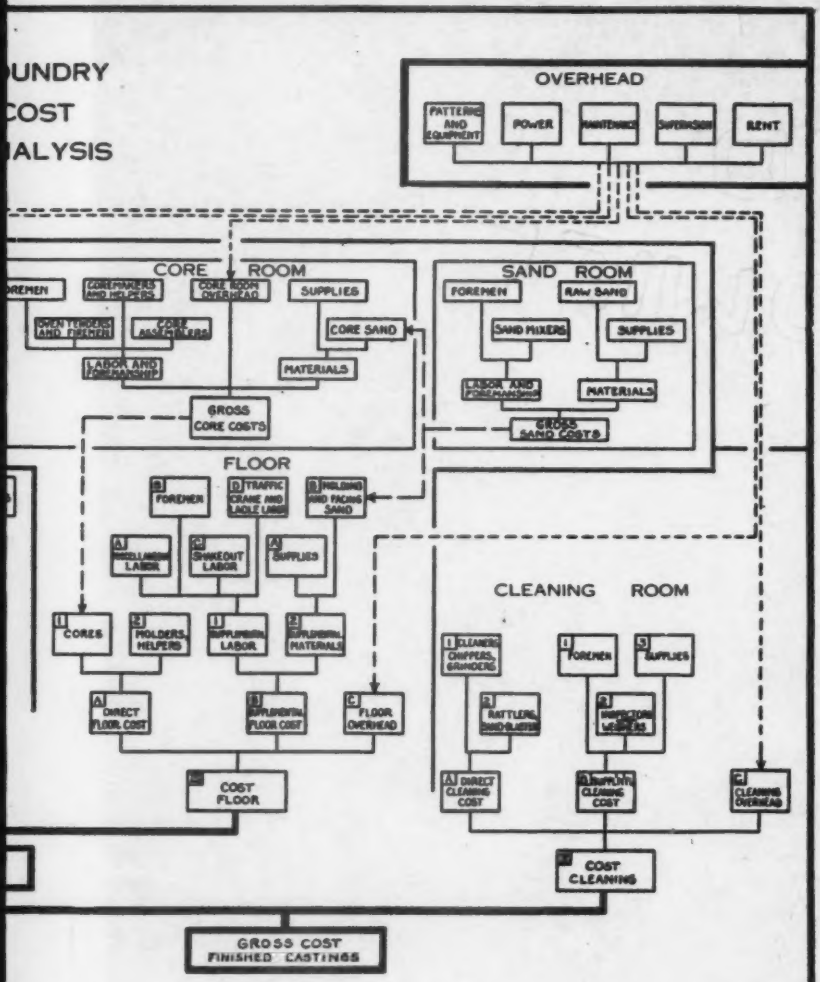
In summary then, it is folly to consider any result but the good output recorded at the finish of cleaning. Here and there foundrymen figure cost in ladle by dividing by the gross pounds melted, without consideration as to whether those pounds will be good or scrap, when finished. Such practice is eminently misleading, and it is strongly recommended that sinners mend their ways, or some day be submerged by the misjudgments which must result.

Distribution to Individual Castings

Having thus considered the problem of determining costs per gross pound produced, there comes in natural sequence the question of distributing those costs to individual castings—or symbol numbers. In the lower left hand corner of the chart is presented a supplementary chart


FOUNDR
COST
ANALYS
STORES DEPARTMENT
INVOICED COST RAW MATERIAL
DISCOUNTS
FREIGHT AND DRAYAGE
STORES DEPT EXPENSE
STORES OVERHEAD
DIRECT COST OF MATERIAL
MATERIAL BURDEN
GROSS COST MATERIALS-SUPPLIES
SUPPLIES CHARGED TO ALL DIVISIONS
FOREMEN
CUPOLAS
PIG YARD
CUPOLA FOREMEN
PIG YARD FOREMEN WEIGHERS
CUPOLA FUELS
SUPPLIES
PIG IRON
FOUNDRY SCRAP
HOME SCRAP
REMELT
HOME SCRAP
REMELT
CUPOLA TENDERS, CHARGERS
LADLE DRYERS, HOOKTENDERS
LIME AND ALLOYS
METAL CHARGED
LESS
METAL RETURNED
LABOR AND FOREMANSHIP
CUPOLA OVERHEAD
CONVERSION MATERIALS
NET COST RAW METAL
COST CONVERSION
COST IN LADLE
COST IN CLEANING ROOM
DIRECT FLOOR COST
DIRECT CLEANING COST
GROSS COST FINISHED CASTINGS
GROSS DIRECT COSTS
DISTRIBUTED TO SYMBOL NO. BY ACTUAL CHARGES
GROSS PROPORTIONATE COSTS
DISTRIBUTED TO SYMBOL NO. BY POUND PROPORTIONS
SYMBOL 1
2
3
4
5
6
ETC.
ACTUAL RESPECTIVE SYMBOL POUNDAGE
RESPECTIVE SYMBOL COST PER POUND

UNDRY
COST
ALYSIS



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intended to explain in brief the operation involved in this latter problem.

Two separate distributions are necessary; the one by direct charge to a symbol for whatever cost may readily be carried to it, the second by proportionate or supplemental charge on a basis uniformly applicable to all symbols. The most uniform basis is eminently the pounds of metal consumed.

In examination of foundry operations it has been established that in general only four detailed costs can readily be charged direct to individual castings. They are the cost for cores; for molders and helpers; for cleaners, chippers and grinders; and for rattler and sand-blast tenders. In the general chart they are assembled as Direct Floor Cost (III A) and Direct Cleaning Cost (IV A). Uniting the two as a gross distributed cost, the supplemental chart shows the method of determining gross proportionate costs, by a deduction of the gross distributed costs from gross costs of finished castings.

First, dividing gross proportionate by the total poundage of good castings produced, a multiplication of the result by the gross pounds contained in the number of castings turned out under the several symbol numbers readily distributes the proportionate cost to all symbols.

The next operation is the distribution of "distributed" costs. This can best be accomplished by the use of what is termed a "service card," which is merely a ticket made out by the office and given to each molder or cleaner whenever his work is turned to the production or cleaning of a new casting. Time, wages, and symbol numbers of castings are recorded on the service cards, which would be returned to the office and exchanged for new ones when the work is completed. Core service cards are merely special forms of the service card and would be issued to a molder as requisition on the core room when cores of any description were needed. Complete record as to the symbol number of the casting for which the core is to be used, together with costs and other needed data, are recorded on the card. And core

cards would be returned each night to the office, to be distributed against the output of the period.

In distributing such charges, the service cards for the period are assembled and assorted by symbol number, the several kinds separately, and complete details of cost are compiled therefrom.

Many methods of recording detailed costs may be in existence. The one named is the only one which can be recommended for completeness and perfect flexibility. Through use of it, not only does the cost clerk find ease in distributing costs to divisions and to individual castings, but, further, the payroll clerk is furnished with simultaneous information as to wages through use of a carbon copy made out when the original is written up.

Aside from the detail of method, however, the essential point is that of individually charging out the items named, at the time when the work is done or the material is used.

Having been properly distributed, the resulting symbol costs are applied against the proper castings and combined with the proportionate costs already named. The only remaining duty is that of dividing individual casting costs by gross individual casting weights; which act will deliver individual total costs per pound for the several kinds of castings produced.

Concerning Cleaning Costs

A word concerning cleaning costs should be entered here as supplement. Owing to the fact that frequently several kinds of castings must be rattled together to fill a drum, it is sometimes difficult to determine actual cleaning charges against respective castings. In such an emergency it is recommended that the castings be divided into classes by weight, and that no two classes be mixed in the drum when rattling. This done, the class cost may be recorded by whatever method is in use for reporting other direct costs and then be distributed by weight proportion to the individual symbols contained in the class. And in such instance, the fewer castings in any class, the more accurate the resulting figure.

Reverting now to the matter of material costs, a natural question may arise as to the best method of apportioning material burden. After due study the only choice is to recommend a basis of direct cost per unit of material. The stores department is in reality a bank whose care is that of real money, though it be in divers shapes and conditions. Its work and responsibility is most likely to vary with the value of the material handled. In consequence any expense incurred is justly that which value causes—therefore value must bear the burden. Material burden should be established by apportionment on the basis of dollars represented by the material in stores; and the cumulative figure for direct and burden cost must unite in a single figure per unit of material delivered.

Assuming, for example, that direct cost for iron were 80 cents a hundred pounds, and that gross burden costs figured at a 25 per cent. rate on the basis of gross direct costs, the charge that would carry against the foundry as gross cost of raw metal would total 80 cents for direct cost plus 25 per cent of direct for burden cost, or $1.00 per 100 pounds.

Costs for supplies would necessarily be handled in similar fashion. So, with supplies being requisitioned by all divisions, proper material charges would automatically distribute themselves to cupola, to floor and to cleaning room—to proceed thence as a part of the complex figure for each division.

Overhead Expense

There remains the problem of proper distribution of overhead expense. Discussion of it calls first for a brief analysis of the structures of the overhead elements. Five divisions most naturally cover the entire subject, namely

(1) Pattern and equipment charges;
(2) Power expenses;
(3) Maintenance costs;
(4) Supervision charges;
(5) Rent;

which last includes building and grounds maintenance, real estate rentals, and other like costs which are ordinarily associated with a rental charge.

Comes the query: Why are not pattern expenses distributed as a direct charge against molding? The query calls for a word in supplement to the chart. In a jobbing foundry, where frequently special patterns must be made for each new casting put in the sand, pattern shop expense must be distributed to individual patterns just as, on the floor, molding costs are charged directly to individual castings. Similarly it would be accomplished by service card, whether for a jobbing foundry or for any other sort. In the case of a jobbing foundry, the gross assembled pattern expense for any individual pattern would naturally have to be carried immediately as a charge against customer for the casting made. In a non-jobbing concern individual pattern cost would be combined with other patterns and the whole charged into overhead for equipment on a depreciation basis.

In the event of such a charge, the pattern shop chart would take a form similar to that of the core room as shown on the chart; having its own overhead, and distributing its own expense for labor and materials to completed pattern output. For both core room and pattern shop, a very logical basis for the distribution of overhead burden would be the number of man-hours expended in the making of the part by coremakers and core assemblers, in the one instance, and by patternmakers in the other.

Service card records would establish direct charges and would give the man-hours record needed as basis for the burden distribution.

The important point in the distribution of overhead is the basis on which charges to divisions are established. Equipment charges must be distributed in the form of daily or weekly cost for its use—such cost being determined in the manner of a depreciation figure.

Power cost most naturally rests upon the consumption of horsepower hours by the divisions—the cost per horsepower hour being determined through records of labor, material and overhead allotted to the power house. Records of consumption by meter are best, but where meters are lacking, estimated horsepower per division will serve.

Maintenance expense comprises materials and labor expended in repairs to equipment of the various divisions. In-so-much as such repairs are of lasting effect, it is not advisable to charge their cost directly against the division when made, but rather to charge daily maintenance expense to a controlling account from which would be determined each month a daily maintenance figure to be carried against output.

Supervision becomes perhaps the most uncertain element of all costs. It is comprised of certain administrative expenses not chargeable directly to any of the other overhead accounts. Salaries of general officers, liability insurance, general office expense and similar items are included. Care must be exercised, however, to guard against abuse of this account by using it as a general dumping ground for expense that the accountant is too lazy to care for properly.

Rent, as heretofore stated, is made up of all those expenses which would come under this heading if the building and ground used were not owned.

Supervision expenses may be charged to operation on a basis of time or material, depending largely on the circumstances surrounding the particular plant in question.

Rental charges should be proportioned in any event on a basis of floor space occupied. By recording square feet area in a division, rental costs are readily brought down to that division at a charge per square foot.

Recapitulation

Reverting, now, to a general examination of the problems of cost analysis, let the following simple facts fix themselves in your memories:

I—There are just three basic causes for expense—
- 1.—Material,
- 2.—Labor,
- 3.—Capital charges.

II—Foundry costs are divided into four clear cut divisions—
- 1.—Metal,
- 2.—Conversion,
- 3.—Floor,
- 4.—Cleaning.

III—The operation of cost analysis is simply the separation of the three basic expenses into charges for each against each of the four divisions.

IV—The reporting of gross foundry cost is merely the reassembly of the analysis to tell the story of operation step by step as the details mass into a cumulative total.

V—The reporting of cost for any particular casting is but the selection of expense occasioned by that casting during its progress through the plant.

In so brief a summary of costs it is impossible to create a system of details that will care for the individual troubles of every foundryman present. But it is possible to recommend a general scheme which may serve as the framework on which individual systems can develop.

In the rectangles contained under pig yard, cupolas, floor and cleaning room, the chart exhibits a Roman or Arabic numeral or a capital or small letter. If you will copy and assemble those symbols in order from pig yard to cleaning room, you will have created the following charge index:

I—Net cost raw metal.
- A—Metal charged.
  - 1—Pig iron.
  - 2—Foreign scrap.
  - 3—Home scrap.
  - 4—Remelt.
- B—Metal returned.
  - 1—Home scrap.
  - 2—Remelt.

II—Cost conversion.
- A—Labor and foremanship.
  - 1—Cupola foreman.
  - 2—Cupola tenders and chargers.
  - 3—Pig yard cranemen and weighers.
  - 4—Ladle dryers and miscellaneous.
- B—Conversion materials.
  - 1—Cupola fuels.
  - 2—Lime and alloys.
  - 3—Supplies.
- C—Cupola overhead.

III—Cost of floor.
- A—Direct floor cost.
  - 1—Cores.
  - 2—Molders and helpers.

B—Supplemental floor cost.
1—Supplemental labor.
a—Miscellaneous labor.
b—Foremen.
c—Shake-out labor.
d—Traffic, crane and ladle labor.

2—Supplemental materials.
a—Supplies.
b—Molding and Facing Sand.

C—Floor overhead.

IV—Cost cleaning

A—Direct cleaning cost.
1—Cleaners, chippers and grinders.
2—Rattlers and sand blasters.

B—Supplemental Cleaning Cost.
1—Foremen.
2—Inspectors and weighers.
3—Supplies.

C—Cleaning overhead.

These are your analysis accounts. If for every element of expense, whether material, labor or capital charge, you provide a proper index from the above table when the expense is incurred, your costs will automatically divide themselves so clearly that any boy can assemble them to accord with the chart. In his introduction to this survey Harrington Emerson suggests the value of a color distinction between the service cards for material, labor and capital charges. Such a scheme has been applied in problems of cost analysis, and has proven to be of extreme assistance, particularly when the system has had to depend for its results upon the work of cheap clerical help.

There are many ways in which the cost index and color scheme can be refined. For instance, were you to assemble all the red labor cards for a day or week, your payroll could be made up directly from them. Similarly could stores consumed be reported from the yellow material cards; and capital charges be recorded from the blues.

By adding to index IIC, IIIC and IVC the Arabic numerals 1, 2, 3, 4 and 5 it is possible to determine how much of an equipment, power, maintenance, supervision or

rental charge is borne by each of the cupolas, the floor and the cleaners.

And so it might continue indefinitely. No man can prescribe a general antidote for all ills, else he may be relegated to the realms of quackery. Long experience, has, however, established certain general rules which make up the basis for every prescription. These rules, for the field of foundry costs, are:

I—Determine your three fundamental expense figures.
II—Separate your operation into clear divisions.
III—Distribute expenses to divisions with scientific care.
IV—Re-assemble division costs into gross direct and gross proportionate groups.
V—Re-distribute direct and proportionate groups to individual castings.

Elimination of Waste Motion in Bench Molding

By R. E. KENNEDY and J. C. PENDLETON, Urbana, Ill.

Previous to the time of systematic investigation and discarding of methods of shop operation, we were happy to believe that we were pursuing the proper course to produce the best results in the quickest way. Now it is apparent that this was a false idea. It is evident that the interest aroused, due to the necessity caused by modern competition to eliminate the waste and inefficient motions of the workers, will be the means of initiating into the foundry many ingenious methods for the increase of production without a corresponding increase in the physical exertion of the workman.

That there are waste motions in all foundry operations, due to improper training, poor tools, and equipment, and a lack of planning on the part of the management is realized by all foundrymen, but the steps taken to better these conditions are comparatively few; the average worker and employer content themselves with the generally accepted practice of past generations of manufacturers. Statistics show that the average workman's efficiency is only a small per cent of what it is possible for it to be, owing to the above named conditions. Much has been done in large plants to eliminate and cut down the motions of workers by the installation of sand conveyors, continuous molding plants, molding machines, etc., but every shop has an almost unlimited number of places for reducing time and cost with only a very small expenditure of money. These changes can be brought about by following out the suggested improvements shown by careful time and motion studies, which reveal better than anything else the opportunities for bettering conditions.

Do you, as foremen or superintendents, know whether your molders have their benches or floors arranged in the best possible manner, do they have the proper tools in good shape, and are they placed where they can be most easily obtained?

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Or are the molders doing more work, such as venting or ramming, than is necessary?

Do you not generally have the idea that as long as they are molders, earning molders' wages, they should know their business? If they are not otherwise instructed, you may be

FIG. 1—TYPE OF MOLDING BENCH COMMON TO A LARGE NUMBER OF FOUNDRIES

sure they will perform their work as they learned it from experience, and a lot of this experience will be of a poor kind. It is not always the man with the most experience who is best at the business, but the man who is able to analyze the experience of himself and others and use it to the best advantage.

Therefore, you can be sure your molders will do many things in an inefficient manner unless the best way of doing the work has been collected together in a standard method of operation

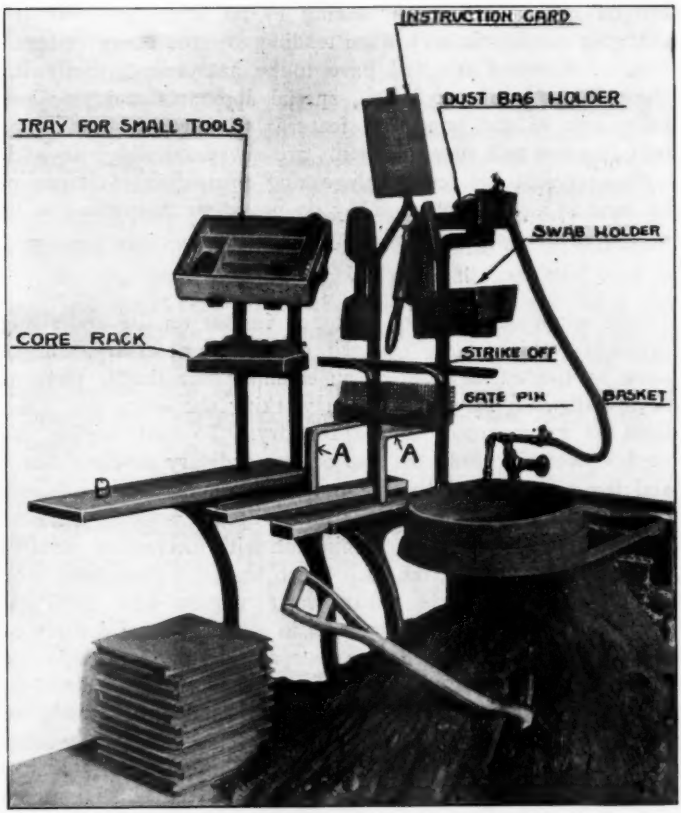

FIG. 2—TYPE OF MOLDING BENCH BUILT TO ELIMINATE UNNECESSARY MOTIONS

routine and the workman, being provided with the best tools and equipment, is taught to use this standard routine.

The time is past when everything can be left to the discretion of the molder. The expertly trained all around molder

mechanic is growing more and more difficult to find because of the tendency towards specialization in the foundry. The complete planning out in advance by the foreman of work is becoming more of a necessity all the time. Cheaper and quicker methods of operation are having to be found to meet the changing conditions, which are tending towards closer competition. All orders received have to be analyzed carefully for cheap methods of production, special apparatus and machines being one of the important features of cheap output. The best foremen and superintendents are always viewing the work with a critical eye, constantly asking themselves if it cannot be done in a better way. They do not allow themselves to be hampered by the traditional way of the past.

Subject of Study

It is not our intention to touch further on the underlying principles which make changed conditions necessary, but to show by the working out of an example how similar methods of investigation may be used in working out every day questions of improvement in the foundry. To best explain the method we will study the use of the ordinary molding bench and the operation of turning out any simple casting in small quantities, too small to pay for fitting up for machine molding.

Outside of its use in combination with mechanical features as a molding machine, the snap bench has been given very little consideration. Knowing that waste motion and inefficient methods were common occurrences in molding, careful study of the operations performed was determined upon. To get the best results which mean in this case the most information, an exceedingly detailed time and motion study was made of different operations on bench molding. This detailed itemizing of the operation may seem useless to many, but it is a *well known fact* frequently proved by time studies that many important facts have been missed by not obtaining for analysis the seemingly unimportant small detail.

Analysis of Conditions

Realizing that it would only be possible to get results by paying attention to the small details of molding and having

decided to see what could be done toward increasing the efficiency of the snap bench molders, time studies were made of men under ordinary shop conditions as they were performing the work when the investigation was first started. The type of bench used, Fig. 1, is familiar to all foundrymen. The results of these studies are shown in the Record of Time Study, Column A.

Analyzing the work done under these conditions, three facts were impressed upon the minds of the investigators:

1.—That one of the causes for delay and lost time was due to not having the tools in the most convenient positions for handling. They were often covered up with unnecessary odds and ends, like unused patterns, extra gate pins, old cores, etc.

2.—The second cause of inefficiencies was attributed to the fact that very often the workman did not have the necessary tools and quite often those he did have were not in very good shape. Blunt draw spikes, inefficient rapping hammers, swabs, sand cans, etc., were quite in evidence when the workman was left to supply his own tools and keep them in shape.

3.—The third large item of lost time was caused by the molders doing too much unnecessary work, such as taking several small shovelfuls of sand to fill a cope or drag when one or two heaping shovels would have produced the same results.

Arrangement of Bench

Studying the shop conditions, it was found best to have the benches made of the wall type, although under the greater majority of cases the portable bench over the sand heap is most economical, due to less handling of sand and molds. This molding bench, Fig. 2, was constructed with the idea of having a place for every necessary tool and all supplies, while having each located within the most convenient reaching distance. The arrangement is such that the tools cannot be placed anywhere but in the proper place, and the foreman or molder can see at a glance whether the tools are in good condition.

With a place for everything actually needed and only those tools and supplies around, the common fault of the workmen of

having their benches littered up with extra tools, patterns, old cores, gate pins, etc., was done away with.

The small tools, slick, trowel, gate cutter, etc., are kept in the tool tray as shown in Fig. 2. The box sets on its stand

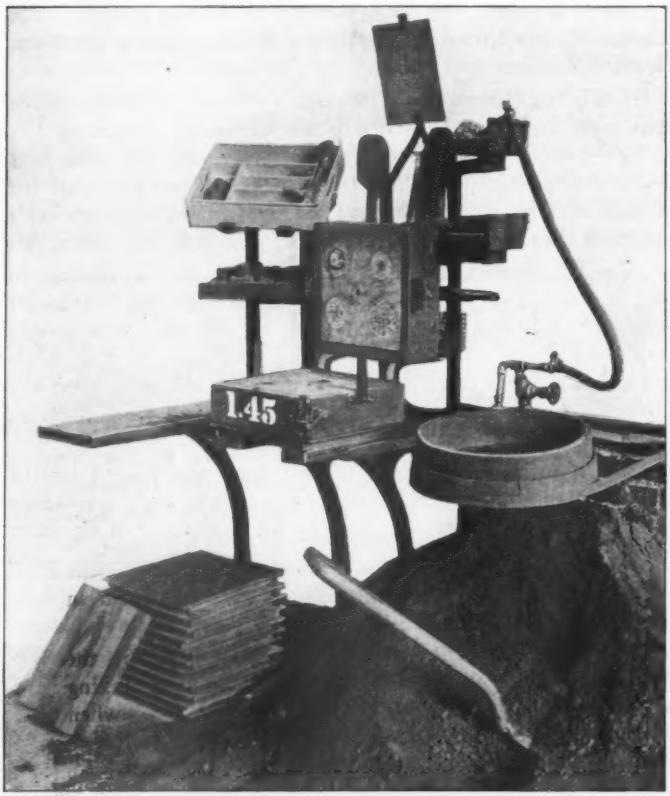

FIG. 3—WHEN THERE ARE NO PATTERNS IN THE COPE, IT MAY BE SET OFF ON BRACKETS

and is tilted at such an angle that the molder can see each tool and get the one needed with practically no loss of time as in searching for it on his bench. This tool box is returned to the tool room each evening when the tool room attendant sees that

the tools are in good shape. If special tools are needed for a particular job, they are placed in the box issued to the molder assigned to that order.

FIG. 4—ILLUSTRATING THE USE OF WIDE STRIKE OFF. ONE SWEEP OF THE IRON LEVELS THE TOP OF THE COPE

Under the tool box is a shelf for holding a core tote board. The rammers and strike-off are kept directly in front,

easy of access and when replaced they can be thrown into their holders with one motion of the arms.

A wire basket holder for the sprue and riser pins is located at the back of the bench. This is a convenient position from which to obtain the pins when needed, the wire preventing the accumulation of sand as in a tight box or shelf.

The two brackets marked *A-A,* Fig. 2, are for setting the cope onto when there are no patterns to be drawn from it. The use of this shelf is shown in Fig. 3. When patterns have to be removed from the cope it is rolled over onto the side shelf at *B,* Fig. 1. The dust bag and swab can holders are placed at the right of the workman for ease of access.

The riddle is kept in the rack at the right side of the bench. Located above the sand, it is never in the way at the side of the bench as in ordinary practice. From this position, sand can be shoveled into it easily and it can be picked up with less trouble than having to reach down to the floor level. This arrangement of the bench for having the tools in a definite place, easy to reach and replace, played quite a part in cutting down the average time of making molds. An analysis of the comparative time studies of Fig. 1, shows where some of the detailed operations were cut down.

Proper Tools

The second item of the main causes of lost time, the lack of proper tools and tools in poor shape, is neglected in the majority of foundries because of the belief that the molders will furnish their own. A glaring example of this was noticed by the authors a year ago in what is supposed to be one of the largest and best shops in the country. One spirit level was common shop property among 15 loam molders, and an enormous amount of time was lost by the men in looking for this tool when needed.

In bench work the shovels must not be worn too small or used with the edges turned. Much effort is wasted when using dirty shovels. In this case a tool room attendant looks after the shovels to see that the edges are in good condition and keeps the blades oiled when the shovels are not in use.

Draw spikes are inspected for sharpness, proper sized gate cutters, swabs, and draw screws are issued to the men. The other small tools are looked after in a similar manner. Bell top sprue pins are used wherever possible because they eliminate time in striking off and in reaming out around the sprue hole.

The use of a special wide strike-off iron, one stroke of which finishes the operation, was instituted on all this snap bench work. The use of this is shown in Fig. 4.

Straight steel bottom boards are used because of their durability. Also the strike-off leaves a smooth surface on the drag and no time is lost in bedding the board on a soft layer of sand.

Unnecessary Labor

The third item, extra work, led to a consideration of such things as molders taking an excessive number of strokes with the rammers, small and many shovelfuls of sand, moving too far for bottom boards, etc.

One heaping shovelful of sand in the riddle was found to be all that was necessary, in the majority of cases, for both drag and cope. The use of many small shovelfuls of sand to fill the cope and drag for peining and butt-ramming was replaced by the use of two and three large shovelfuls. Careful placing of the bottom boards for ease in reaching was observed. These and many other like items of information observed as standard operation methods produced quite a saving in time and labor.

Instruction Cards

Instruction cards are made for the men working with different patterns as the orders come into the shop. These contain information as to the flasks to be used, special tools needed, special gating, how cores are to be set and anchored and other details generally left to the discretion of the molder. These cards are issued to the molder with his tools and work order. Being made up by the most experienced men, they insure the use of the quickest way of making with the best methods of gating, holding of cores, etc. A special place is

provided on the bench for holding these cards where they can be easily read. The value of the written instruction lies in the fact that the best method of making the piece is planned out in advance of doing the work. All tools and special apparatus needed are noted and are gotten together and when ready, the work is started and continued by the molder without the unnecessary delays usually encountered when the work is begun without any forethought being given to it. These cards relieve the foreman of having to repeat verbal instructions and preclude the possibility of misunderstanding which so often occurs.

The use and writing of instruction cards impressed on the management more than anything the need for standardization in tools, materials, and methods of work.

Results Obtained

The following table gives in comparative form the conditions before the work of investigation was started and the outcome of following the suggested improvement.

Record of Time Study

Item.	A Average of studies, minutes.	B Average of studies, minutes.	C Average of eliminated time, minutes.
1. Placing flask on bench. Setting patterns	0.18	0.18	0.00
2. Placing riddle. Fill, cover patterns	0.16	0.13	0.03
3. Tuck around patterns.....	0.07	0.07	0.00
4. Fill drag.	0.15	0.11	0.04
5. Pein ram.	0.11	0.09	0.02
6. Butt ram.	0.07	0.06	0.01
7. Strike off.	0.16	0.06	0.10
8. Place board on drag. Bed board	0.09	0.05	0.04
9. Roll drag over. Remove board	0.09	0.09	0.00
10. Set patterns	0.23	0.17	0.06
11. Set gate. Cover with riddled sand	0.33	0.22	0.11
12. Tuck around patterns.....	0.11	0.11	0.00
13. Fill cope.	0.24	0.17	0.07
14. Pein ram.	0.18	0.12	0.06
15. Butt ram.	0.06	0.06	0.00
16. Strike off.	0.16	0.06	0.10

		A	B	C
17.	Remove sprue pin.....	0.07	0.07	0.00
18.	Life cope. Roll cope.....	0.30	0.30	0.00
19.	Clean gate. Remove patterns from cope. Repair cope...	0.80	0.30	0.50
20.	Rap and draw patterns from drag.	0.47	0.40	0.07
21.	Vent for cores. Patch.....	0.40	0.20	0.20
22.	Set cores	0.17	0.15	0.02
23.	Dust drag and cope.....	0.12	0.10	0.02
24.	Close cope	0.31	0.25	0.06
25.	Remove flask	0.15	0.15	0.00
26.	Set flask on floor.....	0.16	0.16	0.00
		5.34	3.83	1.51

The results of Column A are the averages obtained on the making of molds in ordinary practice while the subject was first being studied. Column B gives the average time of making molds similar to those of Column A, but which were made on the well arranged bench while instructions as to striking off, filling riddle, shoveling and ramming were followed. The savings of time on the different items seem very small, amounting to only a few hundredths of a minute on any one item. Items 19 and 21 produced the largest difference, due to the fact that molders will use patterns which will tear the mold slightly on drawing. The time of patching seems so small that they do not think it necessary to have the pattern repaired.

The savings in time of items 2, 5, 7, 8, 10, 11, 14 and 15 were due to changing of benches which facilitated the handling of tools and supplies and the use of the wide strike-off, bell top sprue pins, steel bottom boards, etc.

The other minor time differences were attributed to the combination of good tools, proper handling of shovels, riddle, rammers, and like items.

These small savings of a minute or a minute and a half on each mold when totaled up for each man for a year's work amount to an astonishingly large amount. One minute less a mold, if the molder is putting up eighty molds a day, means that each day an hour and twenty minutes will be gained for productive labor per man. This begins to seem an appreciable

amount and when figured as in the following table for the year's work of ten men is an extremely important saving:

Amount of Money Saved by Ten Men by Saving a Minute per Mold

1 minute per mold for 80 molds = 1 hour, 20 minutes.
1 hour, 20 minutes for 10 molders = 13 hours, 20 minutes.
13 hours, 20 minutes at rate of 35 cents per hour = $4.66.
$4.66 a day for a year of 300 days = $1,398.00.

This study is only one of the many possible in every foundry, and results of observing and putting into practice the suggested improvements of careful and wise thinking will often show better results than were obtained here. Floor molding, core room work, cupola tending, and all other branches of foundry practice can be analyzed for places to reduce time and costs.

Industrial Pioneering or the Location of a Foundry in a New Territory

By L. L. ANTHES, Winnipeg, Man.

When the growing demand for a commodity brings a manufacturer face to face with the necessity of increasing his production, he is forced into serious communion with his *business soul*. If his trade extends over a far-reaching territory, he probably asks himself, "Shall I enlarge my present plant, or are conditions such that I can or should build in the territory farthest from my present manufacturing operations and thus have the advantage over my competitors in the matter of quick distribution?" The question is certainly a poser and the viewpoints from which it may be regarded are many. If the part of the country from which these increased demands for industrial products emanate, is more or less untried from a manufacturing standpoint,—the problem is more difficult. He may be a thorough master of the local conditions which influence his present place of business, but pioneering (and it is nothing more or less than industrial pioneering) brings with it new experiences, new conditions and invariably unthought of contingencies.

In this resume, I am dealing with the foundry business in particular and I speak with the authority of one who *has gone through the mill* and possibly the mill of adversity. While it is not my desire to intimidate those of adventurous spirit, yet I intend to commend to their forethought certain conditions and probabilities that might not have occurred to them, but which experience has taught me exist in the shape of hard facts. We will deal with a more or less concrete instance and endeavor to show how conditions peculiar to the North American continent are bound to influence industrial progress.

A foundryman produces a tariff-protected commodity which in addition to having a large demand in his immediate vicinity, also is used extensively in a territory a thousand

miles or more from the point of production and a territory given over mostly to agriculture. During the years of unusual prosperity the demand exceeds the production; the local market, that is, the market within a reasonable radius of the manufacturing centre, for various reasons is served first and the more distant market suffers a shortage. Immediately there is an outcry from the starved territory sometimes followed by an appeal to the government to remove the protecting tariff in order that needs may be supplied as the country's own protected industries cannot meet the demand, and as the farmer has little sympathy for the protection afforded the manufacturer and as the agricultural community has no small voice in political matters, it is up to somebody to *move*.

It is usually on the *wave of prosperity* that the manufacturer is possessed with the feeling that expansion is imperative unless he relinquishes a market he can no longer hold with his present facilities. He estimates the total consumption of the distant territory and its possible increase, at the same time bearing in mind the development of the home or local market. If he decides that he can best serve his trade in the distant territory by the erection of a plant there, he begins to *prospect*, providing he is willing to assume the extra overhead it will entail, and *take chances* as to profits.

He considers the advantages and disadvantages of certain locations—the large local demand offset by high taxes if he chooses a city, or low taxes and incidental disadvantages should a small town be his choice—whether the best centre for distribution is more favorable to a locality where raw material, power, labor, fuel, etc., are more accessible—in short, what point holds out the most advantages towards ultimate success.

Where there is rapid development in a new country, there is also what might be termed a *frenzied optimism*. Each hamlet sees in the distant future its own prominence among the great cities, and one of the fondest desires of these would-be Chicagos is to become a manufacturing centre. An industrial commissioner is engaged "to boom the town" and many inducements in the form of free sites, free power,

exemption from taxation, etc., are flung in the face of the prospecting captain of industry. Little wonder if he is dazzled by the glowing recital of golden opportunities. But a word of warning here. Inducements such as are offered by these untried and often diminutive localities should be the last and not the first consideration of the *industrial locator.* If he is shy on capital and cannot start his plant without these aids, the problem is entirely different. But it has often been proven that where the facilities for manufacturing and distribution are best there is the least offered gratis. But after he has considered his location from the standpoint of freight hauls, raw material and labor, together with the advantages of distribution, if the community is keen to give him something, let him take all he can get for he will need it!

Often there is some particular element which makes for success in a certain line of business, such as power, fuel, raw material or labor, and where this particular element is most accessible it is wise to weigh what disadvantages there may be against it before an ultimate decision is reached.

Some commodities are so largely used in a big city that the immediate local consumption alone may be a big consideration after the matters of higher taxation, cost of site, cartage and other expenses incidental to a metropolitan centre have been considered.

Always must be considered the inevitable competition. An iron commodity usually is manufactured on a small margin depending on tonnage for profits, and being a commodity, the element of competition is never removed no matter how far away your competitor may be. This factor regulates your price. Furthermore, a distant market is more likely to be a dumping ground for your competitors in times of depression, so you must be resigned to meet this condition of affairs.

Railway rates and railway hauls are no slight determining factors for failure of success. Where a country is sparsely settled and topographical conditions are against cheap railway operation, you invariably have high freight rates. Added to this, though the raw materials essential to your

particular line of manufacture may not be far removed, the handler of these raw materials posts himself as to your necessity and sometimes you have to pay more for your requirements than if you brought them from some more distant point; in short, you pay a premium for quick service.

Owing to the high cost of cartage, which is in line with the higher cost of living in these new setlements, it is almost unnecessary to state that a plant should be served by a railway spur where buying and selling are done in carload quantities. If a foundryman is situated where he can secure a low *summer rate* on account of lake navigation, let him make sure that he is going to save sufficiently to warrant the large outlay of capital, before navigation closes, for raw materials to carry him through the winter. For he has to buy at a time when prices are usually high and he may find himself financially crippled before spring.

Railroads, as a rule, are not favorable to manufacturing establishments which tend to reduce their long hauls on finished articles at high classifications. Then again, railroads are not inclined to give a wide margin of variation between raw and finished materials where manufacturing is likely to be detrimental to their own interests. So the manufacturer, in a new territory cannot hope to have much advantage over his distant competitor through the difference between freight on raw and finished materials. In fact there are points beyond the *pioneer* to which his competitor can ship at a lower rate that he can, though his competitors' goods have to come double the distance, and on top of this our poor pioneer is paying a much higher rate on all his raw material. When you take into consideration the fact that the heavy freight rates on coke, sand and fire-brick, in short, on everything but iron, contributes nothing to tonnage, and that the combined freight on raw materials may exceed the freight on the finished article over the same mileage, one realizes the significance of high freight rates. Then if you are close to the boundary line of a more thickly populated foreign power with lower freights, then what advantage you have in tariff may be offset by the lower freights accorded your foreign competitor.

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Climatic conditions is a feature that must not be overlooked. Are weather conditions such that your plant can be economically operated the year round? Where conditions are such that you have to contend with thermometer extremes of 50 degrees below zero in the winter and 90 degrees in the shade in the summer, you must of necessity have a costly structure if your employes are to work in comfort. And in these newer districts building is expensive and labor high.

This brings us to the problem of labor—a live question no matter where you are located. The piecework basis of payment is now pretty well establisheed in the manufacture of iron commodities, and in order that thc cost of production may be kept as low as possible, our *pioneer* realizes that he must endeavor to introduce the same system in his new venture. Presuming that piecework is an innovation for the district, how is he to set about introducing it? If there is a labor union in the city for the workmen of his particular trade (and there probably will be) he is met by opposition at once. He must bring with him some of his old hands, men upon whose loyalty he can depend, and who are capable of being pacemakers.

Considerable tact and patience will be required breaking in the unskilled labor he will have to draw upon and he will have a year or more of trials in the form of bad castings, accidents and other drawbacks incidental to creating intelligence out of ignorance. As for the skilled labor he will require, it is safe to say the wages will be high and the workmen independent, and the same may be said of unskilled labor. With depressed commercial conditions your men become more tractable, but that is the time when you least require them. Some manufacturers find it advisable to run their plants to capacity during the long winter months, taking advantage of the more plentiful supply of labor when a great portion of outside work is at a standstill and men prefer an inside job when it is cold. This means an accumulation of stock and the tying up of considerable capital.

One must go through the cycles of good and hard times before he is in a position to feel that he can gage trade con-

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ditions and possible contingencies with a fair degree of accuracy. He may swing along merrily on the crest of a boom year and between seasons work to capacity to be ready for the expected rush when trade again opens, but a depression with its accompanying low prices may settle upon the country and the demand for his goods fall off, and he finds himself with a large stock of manufactured material which he is unable to turn over and which he is forced to carry until such time as conditions right themselves. He has the alternative of closing down his plant with the prospect of reorganizing expenses when he opens up again (for men soon scatter in a new country especially where railroad construction is carried on extensively and farming holds out opportunities), or of operating way below capacity with a disproportionate overhead, which probably means at a loss, in order to hold his men together. And then in a new country there is more or less land speculation and you will find that many of your men will be effected by the seeming opportunities of making some *easy money* by investing their wages in *options* or *lots.* This has an unsettling tendency and the men cannot keep their minds on their work. The high rate of wages paid also puzzles the employer as to what extent he is justified in the recovery of wasted products from his plant—whether the cost of recovery may not be higher than the value of material saved. No matter how thoroughly the *pioneer* understands his costs in his old established plant he will find that new conditions bring about new cost factors and a radically new cost basis will be required in his new shop. Local conditions will intrude themselves and must be treated with proper respect. A new territory is very much like a foreign country and local prejudices and customs must not be regarded lightly. One must adapt himself to conditions no matter what his opinion of these conditions may be. He must go about improving these conditions where they need improvement without creating antagonism which may mean his downfall. He will find it to his advantage to co-operate with other manufacturers in his district for the betterment of general manufacturing conditions and where his neighbors have long been established in business he may find it necessary to take the initiative, exercising considerable

tact, before he can gain the support of those who have possibly resigned themselves to existing conditions and are in no mood to *be shown* by a newcomer. And then again they may be in a position to show him a thing or two which will possibly make his less *cock-sure* of his own ideas as to how things can and should be done.

Where a district has grown without the aid of manufacturers and the demand for commodities is large, the jobber or wholesale distributor is usually found to be strong and often antagonistic to a manufacturer entering a field which he has come to regard as his own. Then arises the question of mutual protection and the problem of trade policy.

One of the big things to consider in laying out a new plant is what improvement one can make over his present process of manufacture. The question of machine moulding, continuous pouring and labor-saving devices, etc., will present themselves. Extreme caution is advisable in this direction and the foundryman must not only consult with experts, but, should inquire into the success or failure other manufacturers in similar lines have met with. Where expensive machinery has been installed it is usually proven that the machine must be kept working nearly to capacity to warrant the investment. Very often the factor between failure and success will be found a very small one indeed, though none the less positive.

The foregoing review may seem an array of formidable arguments against *breaking new ground;* but they are actualities, and if one considers them carefully their force must appeal to him.

A competent organization is usually a matter of time and development—you may have to try out more than one and bring order out of chaos. There will be many incidentals peculiar to new territory generally, and certain territory in particular, such as Workmen's Compensation, Employers' Liability and other features over which the employer of labor has no control. They are all worthy of consideration. The pioneer in manufacturing, like any other pioneer, must have youth, optimism and determination, and a certain amount of *cash in hand.* But first and foremost, he must know his business.

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Discussion of Industrial Pioneering

MR. L. L. ANTHES:—Two or three months ago the question of industrial pioneering or the location of a foundry in new territory, or the extension of existing plants, would not have been considered generally, but the developments in the last three months have changed the situation. Europe has been thrown into a war which has awakened us to the possibility of securing foreign trade. Naturally we turn our eyes to our plant and figure whether or not, if we are going to secure this new foreign trade, our present equipment is adequate to take care of the local demand, that is the demand of our own country as well as what may develop in foreign lands. Another great feature which we have to take into consideration is the recent completion of the Panama canal which certainly is going to facilitate transportation between North and South America. Another point, during the past year we have been down to what we might call rock bottom. Trade two or three years ago reached the high point or peak and is now down to low point with a possibility and I will say a probability that there may be a shooting up to peak again, and with this new foreign trade, we will find that we are inadequately prepared to handle what may come our way. Another point to take into consideration is the possibility that in the new countries where we are going to seek trade that has been held by Europe there will be an awakening to the possibility of developing locally in their own centers, and our idea is to get in there before this movement takes any decided form. They themselves will see the advisability, probably, of putting up prohibitive tariffs to keep out imports in order that they may develop their internal trade, especially in manufacturing lines.

Mr. Kreutzpointner has pointed out the extreme importance of learning the language of the foreign countries to which we wish to export, and I think he has touched upon a very vital spot. Not only do we want to learn the language, but the local trade conditions, and it is not too soon to begin to study what may be done towards securing foreign business.

Evils Embodied in Specialization

By THOMAS D. WEST, Cleveland.

The two main influences that are supporting the modern trend toward specialization, not only in the foundry but in most all other lines of industry are, first, the necessity for cheapening and improving the quality of commodities and second, the desire to open avenues that will permit youths and adults to engage in industry who have had little and often no practical experience in their work. Embodied in this latter tendency are evils that are undermining the very foundations of successful industrial and professional life. Specialization too often permits the inexperienced to make business ridiculous. It greatly encourages the belief that intelligence alone will suffice to achieve success in managing men and work. As long as there remain a few true experts who can be utilized as instructors for the inexperienced the present situation may be endured, but some are now coming to realize to their great sorrow that intelligence, no matter how high, cannot replace experience in managing a business. It should be remembered that the masters developed in the old school are fast passing away. This is indicated not only by our deficiencies in skill and shop practice, but also by other degeneracies that could be mentioned.

The chief excellence of the old school method consisted in its demand that a minor undergo a long apprenticeship in order to obtain substantial experience and knowledge in all the branches of his trade or profession. Today experience is too often so superficial as to be more of a bluff than a reality. Not only are those in the shop suffering from the habit of using specialization as a cloak to sustain inexperience or assumption, but those in the professions as well. With regard to the latter, we were informed by Dr. R. S. Copeland before the American Institute of Homeopathy at Atlantic City, June 29, that courses for specialists are so crowding college curriculums as to cause real medical education to suffer, due to the

supposed importance of the specialist. The value of general knowledge and experience is ignored. This shows the efforts the rising generation is making to obtain only such knowledge as will afford a stepping stone toward recognition as artisans or professional men, without giving sufficient time or study to fundamentals. If space permitted the writer could extend his comment showing the injury specialization is causing at the present day.

It is not to be understood that the writer disapproves of specialization in modern industry. It has many commendable features and can be conducted for the benefit of man without involving any evils. To aid in this, a few facts should be forced to the front that will help greatly in bringing about a change in practice for the benefit of all concerned.

First.—The foundation work underlying the skill of artisans and professional men is not due to the efforts of specialists but general experts.

Second.—Specialists could not exist without utilizing some of the general expert's knowledge and experience.

Third.—A general expert can work into a specialty with a great deal more expediency and effectiveness than the novice who specializes from the start.

Fourth.—Every artisan or professional man can find a greater opportunity for becoming familiar with underlying principles in general practice than in special work.

Fifth.—The more all-around or general knowledge and experience an artisan or professional man possesses, the better specialist can he become if he desires.

Sixth.—The broadly trained and experienced men are much less likely to make errors and are better qualified to advance the art or science of their vocations than specialists lacking in such general experience and knowledge.

Specialization in the Foundry.

In the foundry, specialization has been very injurious not only in decreasing the number of skilled journeymen but in causing direct loss in knowledge of the art. In this as in most

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other vocations there has been a struggle by the young to avoid giving the necessary time to apprenticeships. This has caused the supervisors of our jobbing, as well as specialty shops, to permit apprentices to assume the role of journeymen by practicing but one or two of a dozen or more manipulations in which they should be thoroughly experienced. This has led to various evils, one of which appears in the difficulty foundrymen now experience in obtaining molders, superintendents or foremen of high executive ability that are competent to take charge of the cupola, the core room, the molding floor and to be experts in the actual work of all these three branches.

In many foundries general superintendents are now to be found who were selected from pattern makers, chemists, engineers or machinists due to their possession of high intelligence and executive ability, who have had but little if any experience in the actual work of the above branches. Again, a foreman who is familiar only with molding, core making or cupola work may be given supervision over the whole three branches, or each branch may have an independent foreman under a superintendent inexperienced in any of the branches. This can cause no end of contention, lack of harmony, losses, etc. This is all wrong, or at least not what it should be. No one can excuse such toleration of evils on the ground that bright, intelligent youths, who may develop a high order of executive ability, will not learn a trade from A to Z as they should.

The superintendent or leading foreman of a foundry should have had broad experience in all details of the work involved in producing the line of castings that are being made under his supervision. The chemist, cupola men and coremakers should be controlled by him as a part of his working force as are the carpenters, blacksmiths and the repair force. If an intelligent, qualified youth starts early, instead of wasting time in useless studies or frivolities, and sticks to business he can easily become master of all the branches of his vocation. We know some will admit this is all true and ask how it can be accomplished in the face of existing conditions.

The present decadence in skill and experience in such trades as founding which involves hard, dirty work can be

eliminated to a large extent by working out the following suggestions:

First.—Have everyone interested in or connected with the education and training of the young, influence them to continue their apprenticeship until they have gained the necessary insight into their vocation.

Second.—Advance the doctrine that the greater the general experience and knowledge of the specialist, the greater will be his achievements in his own particular line.

Third.—Create agencies that will develop and foster the conviction that the skilled and efficient workers in the trades that besmear and callous the hands are justly entitled to a wage rate far in advance of that paid to those engaged in clean clerical work that involves very little responsibility or sacrifice of time in the apprentice period.

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A Cast Iron with Unusual Structure

By K. W. Zimmerschied, Detroit.

From time to time a number of able articles on the structure and properties of cast iron have appeared treating, collectively, of all the grades and varieties of metal. In the examination of many samples of iron entering into the structure of important automobile parts, the writer has had a good opportunity to test the theories presented in these articles, by applying them to the structures encountered. In the main, these theories are well borne out by the facts in practice: often we encounter cases, however, wherein the hypotheses advanced do not suffice to explain the situation entirely. There seem to be additional factors entering into the problem which need elucidation, and we hope to be able to go into these at some future time. The purpose of this article is to present a rather unusual case, in substantiation of published theories, in as untechnical a manner as the subject allows, first sketching as briefly as possible the substance of these theories.

Ever since Professor Henry M. Howe's presentation of his conceptions, cast iron through its whole range from malleable to white iron has been considered in the light of an extension of the steel series, in which the graphite, when present, plays the role of a large admixture of foreign matter. This steel matrix may, exclusive of the graphite present, be itself either low or high in combined carbon, and may vary within wide limits as to the amount of other elements present. The properties of any good sample of iron will therefore depend upon (1) the properties of the steely matrix, and, (2) the physical influences of the substances embedded therein.

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In the case of black-heart malleable iron, where all the carbon in the interior of the casting is in the combined form after the annealing processes, the properties of the finished part are very similar to those of a very low carbon steel, as is well known. There are other products which have similar characteristics, one of which is shown in Fig. 1. This iron is free from combined carbon, and has been so slowly cooled that the graphite is present in large plates. It is therefore very much like an annealed malleable casting in the large amount of free iron present but is very different in the condition of the uncombined carbon and this difference is manifested by the much greater brittleness caused by the large graphite plates. It happens that the sample pictured in this photograph contains enough phosphorus to give rise to phosphide-carbide eutectic, which is very clearly shown in the center and between two large plates of graphite, embedded in ferrite or pure iron. This constituent adds to the brittleness of this sample.

In Figs. 2 and 3 is illustrated an iron containing some combined carbon. Fig. 2 is a sample etched with picric acid and photographed at a magnification of 100 diameters. In it we find a very considerable amount of graphite, which is present in black curved plates; between these plates we find a large amount of dark material, and surrounding them a considerable amount of a white constituent, which is pure iron or ferrite. The structure of the dark material is better seen in Fig. 3, taken at 500 diameters. It is very likely that the primary graphite plates in this sample were formed by the decomposition of carbide, while the iron was still in a mushy condition, that is, viscous enough to allow the crystals of this element to take their natural form. As the metal cooled, there was additional decomposition of the surrounding metal, which resulted in the formation of pure iron on the one hand and of deposited graphite on the surface of the original plates on the other. It seems that the presence of a small amount of graphite acts as an energizer in the decomposition of additional carbide, which explains the circumstance that the crystals of free iron are very seldom isolated in the middle of the dark areas, but are most often found surrounding the primary graphite crystals.

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The dark areas consist of eutectic, which is known to metallographists and probably to the most of those who have paid any attention to this study, as pearlite, that is, a constituent which contains about 0.90 per cent of combined carbon and which occurs in slowly cooled steel. It is composed of alternate plates of carbide of iron and of iron and, since the carbide is a hard and brittle substance, its effect upon this structure is to reinforce the ferrite associated with it and to strengthen it, very much as steel bars reinforce and strengthen a mass of concrete. It goes without saying, therefore, that, the higher the pearlite content of an iron or steel, all other things being equal, the higher the tensile strength and the lower the ductility of the metal as a whole.

Causes of This Phenomenon

Concerning the causes which underlie the occurrence of these constituents, and the relative amounts of them, it is well known that the balance between silicon on the one hand and sulphur and manganese on the other, taken together with the rate of cooling, exert the greatest influence. As the percentage of silicon rises or as the rate of cooling increases, the amount of free carbon increases and the amount of ferrite or pure iron also increases; conversely, as the amount of sulphur or manganese increases or as the rate of cooling decreases, the amount of combined carbon increases and the percentage of ferrite decreases.

The first effect of increase in the combined carbon is to cause an increase in the amount of pearlite with a corresponding increase in the strength of the iron. When this has progressed to such a point as to give us a structure made up entirely of pearlite and graphite we obtain an iron which is the strongest possible in tensile strength, although it is not necessarily the most resistant to shocks, on account of its greater brittleness. When the amount of silicon is sufficiently reduced however, we come into the next stage where the amount of combined carbon rises to such an extent that it exists as carbide in excess of the carbide contained in the structural entity which we have described as pearlite. An example of this condition is given in Figs. 4 and 5, which

illustrate an iron containing 2.15 per cent silicon. In Fig. 4, taken at 100 diameters from the etched specimen, we find again a considerable amount of white material. In this case, however, it has a very different form from that seen in Figs. 2 and 3 and is very easily distinguished from ferrite in the original sample, owing to the fact that it stands up from the surface in decided relief, after polishing. This constituent contains free carbide in excess of the carbon occurring in pearlite and is so hard and brittle that it has an even greater influence upon the brittleness of the iron in which it is embedded. than has the graphite with which it is also associated. An examination of Fig. 5, taken at a magnification of 500 diameters, shows how this white, high carbon constituent occurs embedded in the pearlite and also shows the very finely divided condition in which the graphite occurs, the latter being scarcely distinguishable in its background of pearlite. It happens that the sample pictured here was cast in a thin section and that it is also quite high in phosphorus. These two circumstances have the effect of causing the graphite to be deposited rather late, after the iron has become too stiff to allow the carbon to take its natural form, with the result that it occurs most frequently in such cases, in very small particles.

Limits Are Narrow

From the above examples and discussion it will be seen that the limiting conditions for obtaining an iron of ideal structure cover only a very narrow range. We have met with a number of irons in automobile castings which approximated this structure, but have only one good sample which can be said to consist entirely of pearlite and graphite, with the possible admixture of manganese sulphide. The analysis of this iron is given in the table at the close of the paper; it is seen to run considerably higher in silicon than the iron in Fig. 1 and will therefore, all other things being equal, be expected to run higher in uncombined carbon; the amount of sulphur, however, is also much higher and this element has such a strong influence in holding the carbon in the combined form that the effect of the silicon is overcome to the end that the steel matrix is practically "eutectoid."

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Fig. 6 illustrates the center of a one-inch bar, the photograph being taken at a magnification of 100 diameters, from the polished, but unetched surface of the iron. Fig. 7 is taken at a magnification of 500 diameters, under the same conditions. These two pictures show the medium sized curved plates of graphite and between these we find the globular patches of manganese sulphide in Fig. 7, these being so pronounced on account of the high sulphur content of the iron. In Fig. 8, taken of the etched surface, at a magnification of 500 diameters, we find that the internal structure is made up of the same graphite plates which are prominent in the unetched sample, surrounded entirely by sharply defined lamellar pearlite, without any evidences of ferrite on the one hand or of cementite or free carbide on the other.

Structure Near Edge of Bar

Figs. 9 and 10 show the structure of the unetched iron, at 100 and 500 magnifications again, at a point near the edge. The quicker cooling on the outside has given rise to a characteristic pseudo-crystalline structure, which structure forms a very interesting study by itself. Suffice it to say that at this time, however, we again have graphite in finer plates than occurred in the center of the casting, although the internal structure as given in Fig. 11 is practically the same. In the center of this photograph is a rather large dark area, in which the lines of pearlite are much less distinct than in the lighter portions. A close examination under the microscope however, reveals the fact that the substance is practically a mass of very fine pearlite, in which is embedded a considerable amount of rounded graphite. The presence of a very few small areas of free carbide in this photograph can also be attributed to the quicker cooling near the edge which has allowed insufficient time for the establishment of perfect equilibrium.

It will be noted that the combined carbon in this sample is reported as being 0.64 per cent, which is considerably below that generally ascribed as pure pearlite. This circumstance is explained in part by the unavoidable errors which creep into the methods of analyzing a cast iron for combined carbon; since our only methods for determining this constituent are

either by analyzing for total carbon, then substracting from this the result of an analysis for graphitic carbon; or else by determining it directly by the color method. It will be seen that one procedure is at least open to the combined errors of two indirect determinations, only one of which can be said to approach the exactness of our other chemical methods; the other depends upon the accuracy of a colormetric determination of doubtful reliability. In the second place we must deduct from the total weight of iron, the amount of other impurities present, in order to arrive at the amount of combined carbon which would count for total pearlite in the steel matrix and, third, it has not been established beyond a doubt that total pearlite always consists of exactly 0.90 per cent carbon.

In support of the contention that the increase of pearlite accompanies an increase in strength, we would note that the tensile strength of this iron averaged 42,000 pounds per square inch. Most of our irons, which approximate the structures shown in Fig. 2 and 3, run between 32,000 and 36,000 pounds per square inch.

Free from Shrinkage

Concerning the question of shrinkage, which will probably occur to the practical foundryman, we might state that this iron is admirable in its freedom from the shrinkage which is liable to occur with many other structures, notably those higher in combined carbon. The graphite is liberated at a time during the solidification when the freezing shrinkage is large, thus counteracting the tendency to sponginess; later on in the cooling, the transformation of combined carbon, which is present in the form of dissolved carbide into the plates of free carbide which form, with ferrite, the matrix of pearlite, causes again a slight expansion which decreases the amount of total shrinkage occurring in the casting.

KEY TO FIGURES AND COMPOSITIONS.

Chemical Composition.

Figure.	Magnifications.	Etching Medium	C. C., per cent.	G. C., per cent.	T. C., per cent.	Mn., per cent.	P., per cent.	S., per cent.	Si., per cent.
1	500	Picric	Trace	3.52	3.52	0.42	0.409	0.027	2.53
2	100	Picric	0.25	2.48	2.73	0.52	0.316	0.114	3.12
3	500	Picric	0.25	2.48	2.73	0.52	0.316	0.114	3.12
4	100	Picric	0.79	2.48	3.27	0.26	1.221	0.090	2.15
5	500	Picric	0.79	2.48	3.27	0.26	1.221	0.090	2.15
6	100	Polished	0.64	2.30	2.94	0.47	0.137	0.136	3.12
7	500	Polished	0.64	2.30	2.94	0.47	0.137	0.136	3.12
8	500	Picric	0.64	2.30	2.94	0.47	0.137	0.136	3.12
9	100	Polished	0.64	2.30	2.94	0.47	0.137	0.136	3.12
10	500	Polished	0.64	2.30	2.94	0.47	0.137	0.136	3.12
11	500	Picric	0.64	2.30	2.94	0.47	0.137	0.136	3.12

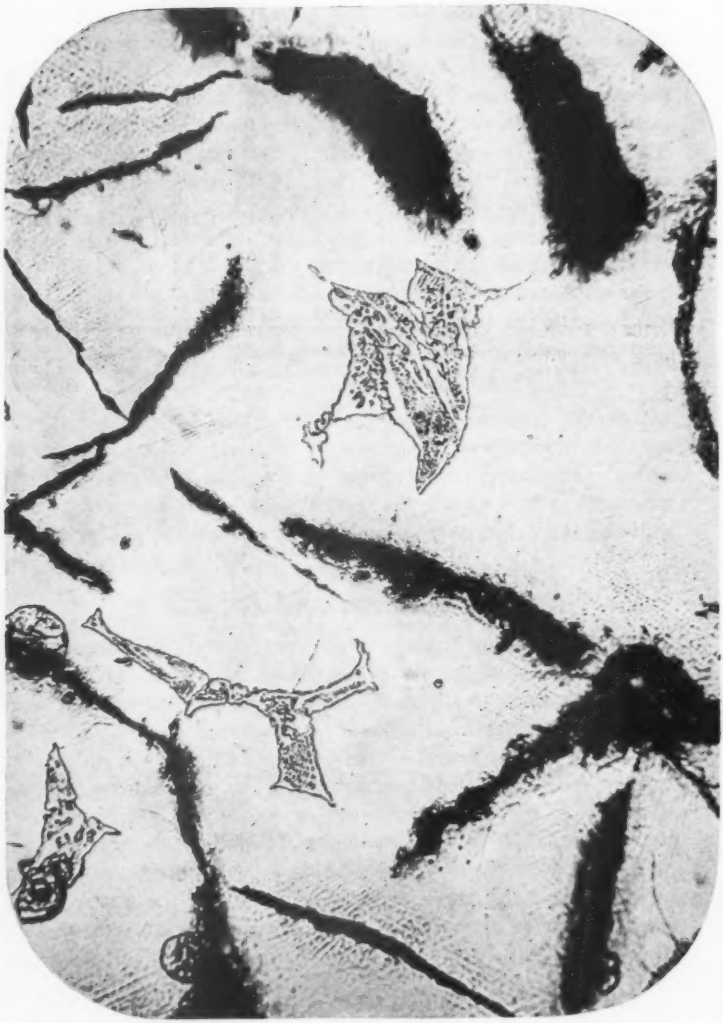

FIG. 1—IRON WITH GRAPHITE PRESENT IN LARGE PLATES
Magnified 500 Times and Etched with Picric Acid

FIG. 2—IRON CONTAINING SOME COMBINED CARBON
Magnified 100 Times and Etched with Picric Acid

FIG. 3—STRUCTURE OF DARK MATERIAL SHOWN IN FIG. 2
Magnified 500 Times and Etched with Picric Acid

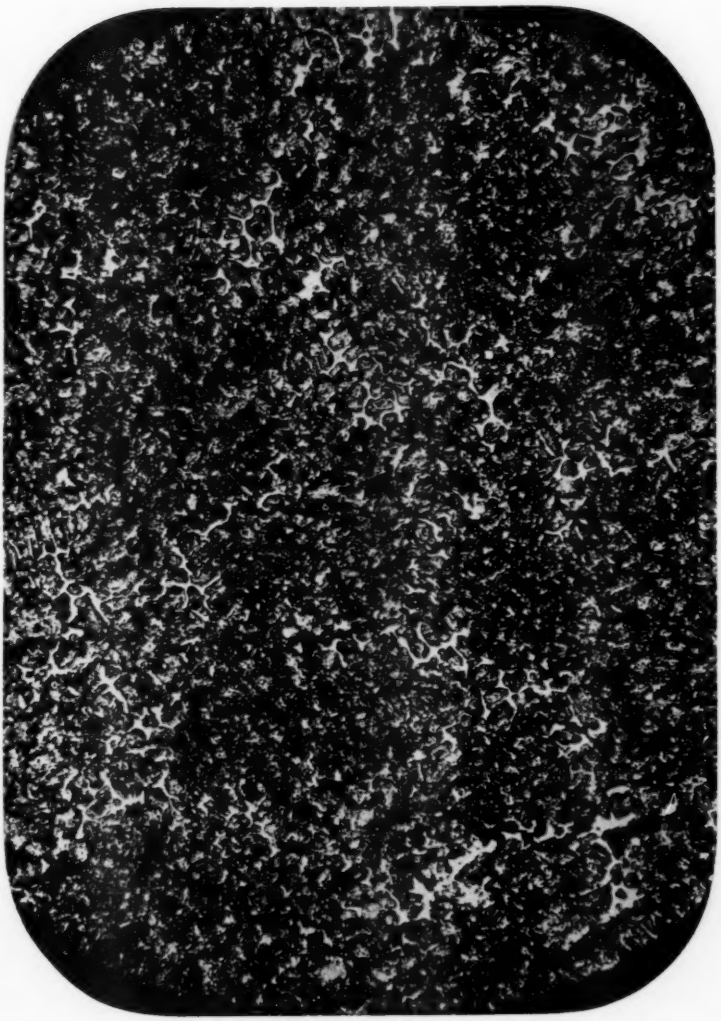

FIG. 4—IRON WITH CARBIDE STRUCTURE
Magnified 100 Times and Etched with Picric Acid

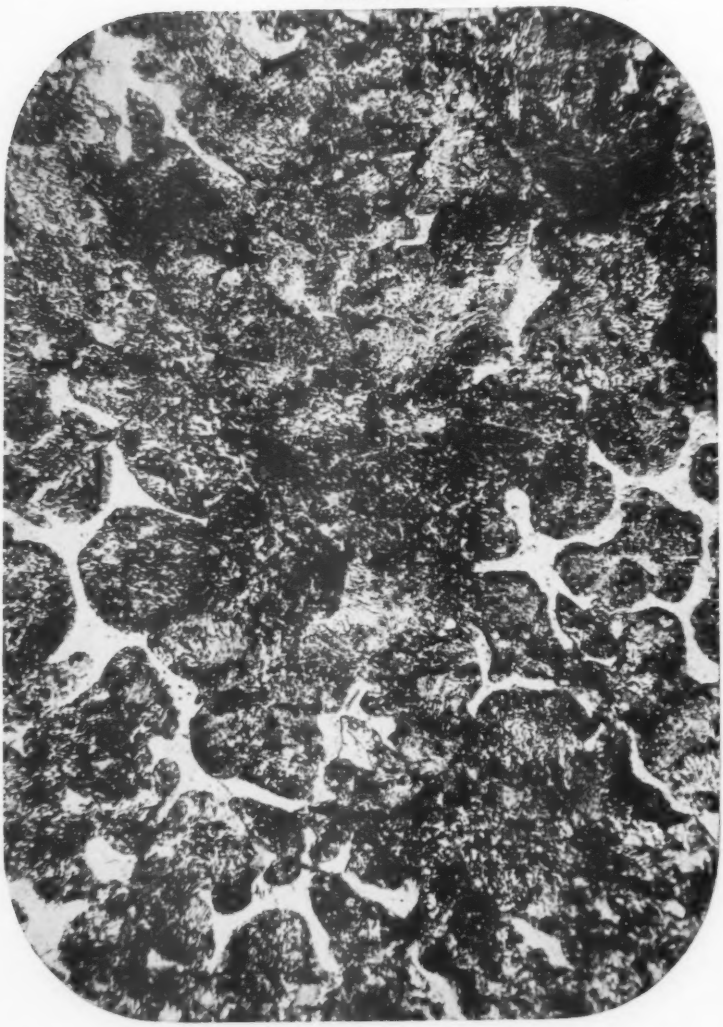

FIG. 5—STRUCTURE OF THE WHITE, HIGH CARBON PORTIONS OF IRON SHOWN IN FIG. 4
Magnified 500 Times and Etched with Picric Acid

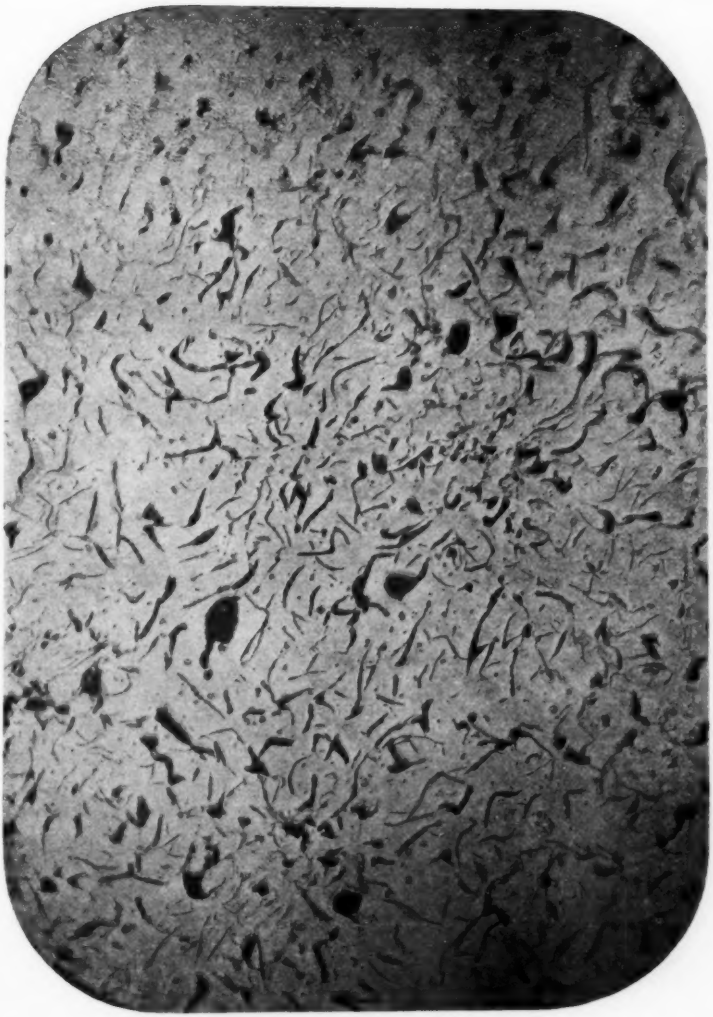

FIG. 6—CENTER OF A 1-INCH BAR
Magnified 100 Times and Polished

FIG. 7—SAME SECTION AS SHOWN IN FIG. 6 WITH INCREASED MAGNIFICATION
Magnified 500 Times and Polished

FIG. 8—STRUCTURE OF BAR SHOWN IN FIGS. 6 AND 7
Magnified 500 Times and Etched with Picric Acid

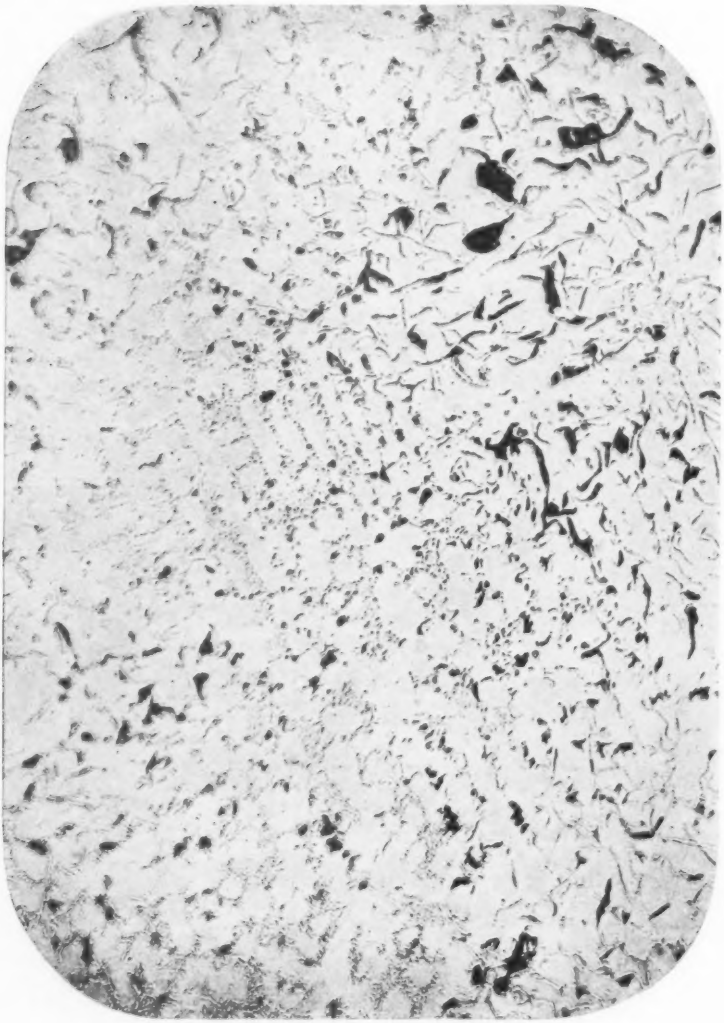

FIG. 9—STRUCTURE NEAR EDGE OF BAR SHOWN IN FIG. 6
Magnified 100 Times and Polished

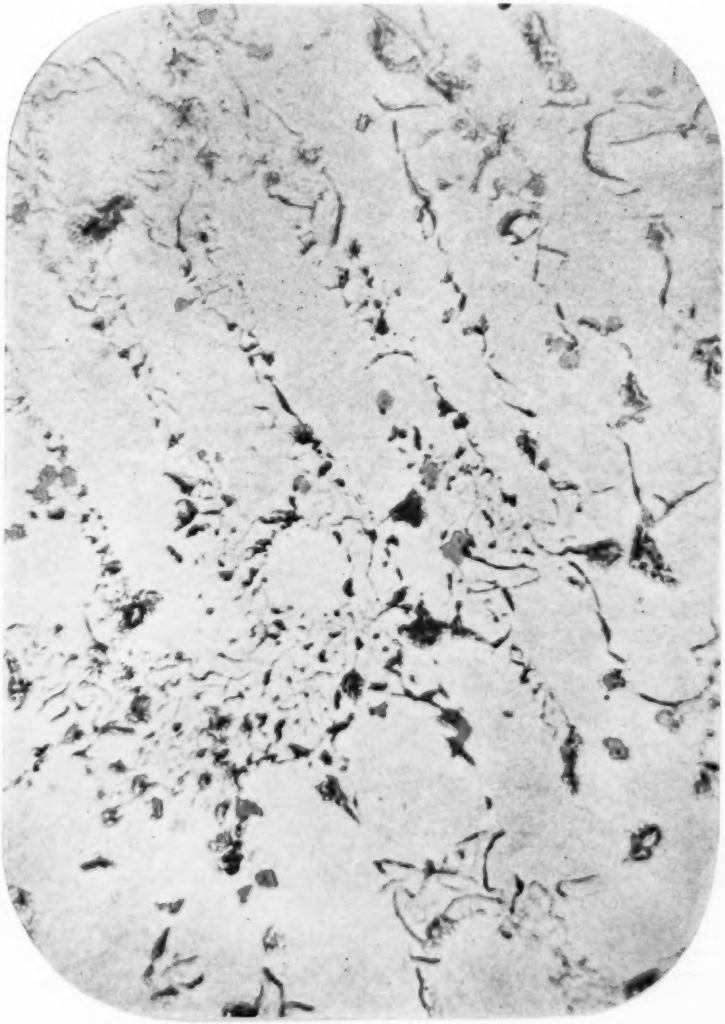

FIG. 10—STRUCTURE NEAR EDGE OF BAR SHOWN IN FIG. 6
Magnified 500 Times and Polished

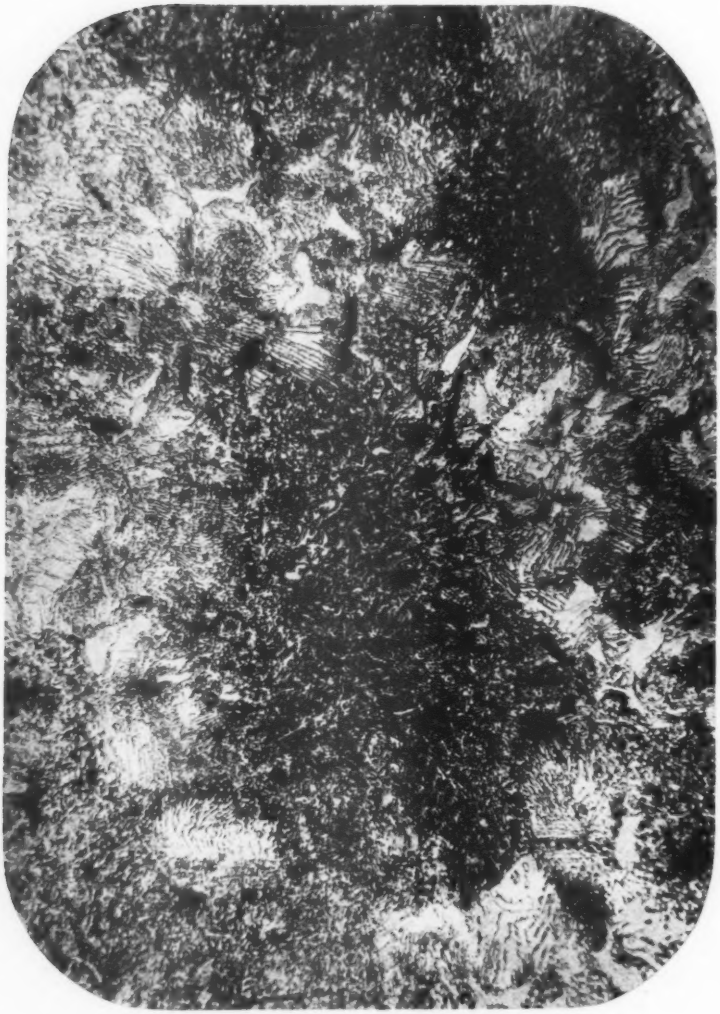

FIG. 11—INTERNAL STRUCTURE OF BAR NEAR EDGE
Magnified 500 Times and Etched with Picric Acid

Discussion of Cast Iron with Unusual Structure

MR. KEATON:—You say that test bar broke at 42,000 pounds?

MR. H. B. SWAN:—Yes, 42,000 pounds tensile strength, about 4,500 to 5,000 pounds transverse strength.

MR. KEATON:—What analysis have you?

MR. H. B. SWAN:—The analysis is given on page 341 in the paper. From No. 6 down the silicon is 3.12 per cent. I might say that a good many men hold the idea that high silicon does not go well with good wearing qualities, but the people who manufacture this grade of iron tell me that there have been tests made for wearing qualities of irons obtained from three or four other standard foundries; and, if I am not mistaken, after a year's service the oversize of the cylinder from this particular foundry was only something like 0.0005-inch compared with about 0.007-inch with the others tested. As far as laboratory tests are concerned on this iron, we have not finished them yet.

A MEMBER:—I notice a statement made here that with this iron, as the rate of cooling increases, the amount of free carbon increases; is that correct? I am speaking now from the standpoint of using a chiller on iron to increase the rate of cooling and catch the carbon in the combined state, the idea being that the increased rate of cooling will catch the carbon in the combined state rather than in the free state.

MR. H. B. SWAN:—Yes, but there is another change from the combined form to the pearlite, a transition change, depending, of course, upon the amount of the other constituents present.

THE MEMBER:—Is this pearlite state that you speak of the "white chilling"?

MR. H. B. SWAN:—No, the pearlite is the eutectoid of the iron (ferrite) and the carbide of iron.

THE MEMBER:—Isn't it true, then, that as the rate of cooling increases in the presence of the chiller, that the amount of combined carbon would increase?

MR. H. B. SWAN:—Yes, it probably would. If you left that casting in the sand a long time and had slow cooling, you might decompose the carbide somewhat into pearlite.

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THE CHAIRMAN, MR. ALFRED E. HOWELL:—Isn't the sulphur rather high—0.137 per cent? And yet, with that high sulphur, you say it's a safe casting with a low shrinkage?

MR. H. B. SWAN:—Yes, it is; you see you have very high silicon to offset your sulphur; the balance of the two seems to get the structure desired. Of course your phosphorus is very low; that may also have something to do with it.

THE CHAIRMAN:—Did Mr. Zimmerscheid communicate to you what the shrinkage of that iron would be?

MR. H. B. SWAN:—I think about 0.1-inch to the foot.

THE CHAIRMAN:—That would be a very low shrinkage.

MR. H. B. SWAN:—A very low shrinkage.

THE CHAIRMAN:—In fact 0.125-inch would be quite a low shrinkage; so a tenth would be quite low, lower than I have ever had any shrinkage in my foundry.

MR. H. B. SWAN:—It is lower than in our foundry.

THE CHAIRMAN:—Does he mean a "low" iron?

MR. H. B. SWAN:—The iron will run cylinder castings, but you must use dry sand molds almost entirely; some loam work may be cast, but it has to be poured very hot.

THE CHAIRMAN:—In your opinion, then, an iron of that kind, with that very low phosphorus, would not be fluid enough for light castings?

MR. H. B. SWAN:—I should say not; I don't think you could pour green sand work with it successfully.

MR. M. LA RUE:—Does it machine soft, I mean easy; or is it difficult to machine?

MR. H. B. SWAN:—The Brinnell hardness, I believe, runs around 220, which is fairly hard, and at the same time it machines well and I believe the loss in the machine shop in castings is materially smaller than with other mixtures.

A MEMBER:—It doesn't seem possible to me that a fellow can hold his silicon up to 3 per cent and have his test bars break at 4,100 pounds transverse strength.

MR. H. B. SWAN:—That's the case, because I have seen the bars myself.

THE MEMBER:—I am not disputing your argument at all, but I make these bars myself, make them every day, and I am very much interested. I am looking for the best I can get.

I want to get a strong iron and I still want to get a good wearing metal, and of course I make some chilled bearings, too, and I would like to hear a discussion on the subject. My test bars break at 2,500, 2,600 and 2,800 pounds. We make light agricultural castings. My iron is 2.25 silicon, 0.45 manganese, and we keep down to about 0.08 sulphur, with a phosphorus content that runs about 0.3. We never let it get above 0.5 per cent, and my test bars break all the way from 2,500 to 2,800.

MR. BAUER:—I think it is a very reasonable proposition to get the strength claimed on those bars, notwithstanding the high silicon. There are three other elements in there in quantities way above the average, all of which tend to increase the strength.

MR. H. B. SWAN:—The combined carbon in the iron is probably higher than 0.64. When you begin to get up around 0.70 to 0.80 per cent combined carbon, especially with low phosphorus, you get an iron that is very strong.

A MEMBER:—In agricultural shops you could not have phosphorus so low.

MR. BAUER:—It simply goes back to the point made before, that all of us look to silicon and nothing else. This is a very unusual analysis; there isn't a foundryman in this room that ever made a casting that analyzed like that, but it is theoretically very reasonable.

A MEMBER:—Does Mr. Zimmerscheid suggest any method for controlling the production of this quality of iron?

MR. H. B. SWAN:—Mr. Zimmerscheid does not run a foundry, he simply makes tests on various irons; but I don't think there is any difficulty about getting any mixture you want.

MR. S. D. SLEETH:—We once had a sample casting sent to us which, it was claimed, was too hard for machining. We analyzed it and found the silicon to be 2.68 per cent. Everything else was all right except the total carbon. The latter amounted to only 2.8 per cent. Ninety-nine times out of a hundred we call for total carbon and run our total carbon up and our silicon down in buying pig iron. Years ago we used to run silicon up and didn't pay much attention to the carbon; we used to run silicon up to 2.50 per cent because we wanted it to machine very rapidly. We get it down now to

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1.90 per cent, but pay attention to our total carbon and phosphorus; we also run the sulphur down pretty low. When we buy, we particularly watch for total carbon.

THE CHAIRMAN:—Are you also very particular about your manganese?

MR. S. D. SLEETH:—No, not so particular; it runs about 0.45 per cent, or perhaps 0.50 per cent.

THE CHAIRMAN:—That's in the pig iron?

MR. S. D. SLEETH:—Yes, sir.

A MEMBER:—I never heard of anybody specifying carbon. I don't. Of course if that's a good way to buy, I would like to do it. Nearly all irons have about 3½ per cent total carbon. I have not had occasion to see any that ran up any higher than that. I always aim to keep the phosphorus as low as I can to run my castings; that is, about 0.3 per cent, or not over 0.5 per cent; manganese, 0.45 to 0.50 per cent. If my sulphur runs up on me, I increase the silicon. That takes care of it.

MR. WALKER:—I notice by the abstract of this paper that the work that was done was done on a 1-inch test bar. I would like to find out whether that was a square test bar or a round test bar. Now, we at the Pennsylvania Railroad, cast test bars every day and we cast 1¼-inch round test bar, according to the A. S. T. M. specifications, and as I understood it last year, the Foundrymen's Association adopted that test bar. It seems to me that if we want to get at any figures at all, we should all work on the same diameter of test bars.

MR. H. B. SWAN:—This work was done on both the 1-inch square and on the 1¼-inch round standard test bar that you speak of.

MR. WALKER:—Let me ask you was that 4,100 pounds on this inch square test bar, transverse strength?

MR. H. B. SWAN:—Yes.

MR. WALKER:—It is unusual.

MR. H. B. SWAN:—I don't think it is an unusual figure for transverse strength.

MR. WALKER:—It is with us. We make test bars every day. We come within reasonable limits of your analysis except the phosphorus, and we don't try to get anywhere near 0.13 per cent phosphorus because it would freeze our iron so

soon that we couldn't handle it at all in our gray iron or our soft iron work.

MR. H. B. SWAN:—That's just the point. Some one asked a few minutes ago whether this mixture could be duplicated. There's no trouble whatever in duplicating it. If your pig iron doesn't run high enough in sulphur and you can use Connellsville coke, you will get the same result.

MR. WALKER:—What do you call high sulphur coke?

MR. H. B. SWAN:—I would say around 1.25 per cent.

MR. WALKER:—We buy Connellsville coke right along.

MR. H. B. SWAN:—You can get it running under 0.7 per cent sulphur, but it's like this, every foundryman has conditions that he has got to meet in his own shop, and he has got to pick an iron that will fit those conditions best. An iron such as described in this paper couldn't be run in light work and green sand; you might run it, but would have a high percentage of loss and shrinkage or else you would have to change your system of gating. Usually a foundry has some particular method by which they gate their castings. I know that in our own factories we use very thin and fairly wide gates; quite a number of gates; but with an iron such as described you'd have to have very heavy, thick gates, and unless you care to make the changes in your own shop to suit the conditions which a particular iron demands, I don't believe it pays you to make them.

MR F. P. BASSETT:—I am inclined to agree with our friend from the Pennsylvania Railroad that 5,000 pounds transverse strength is unusually high. In my travels around among several hundred foundries, I don't remember having found any instance where a 1-inch bar would break at any such figure; about half that, I think, would represent the average. Ordinary gray iron mixtures I would say would break at from 1,800 to 2,400 pounds. Where a mixture of steel scrap is used, the strength would probably be increased without difficulty up to 3,500 pounds; but I would say that 5,000 pounds was exceptionally high. I haven't seen it.

MR. H. B. SWAN:—Some of these bars run as high as 5,000 pounds. You will recall Mr. J. E. Johnson's paper, which was read Tuesday. I know absolutely that some of the bars he made, 1¼-inch round bars, broke at 5,000 pounds.

Iron and Its Properties

By Peter F. Blackwood, Detroit.

Iron is certainly the most important of the metals, the master metal which commands all the rest. It is to it that to no small extent is due the present social and industrial position of the civilized world. There can be no better test of the industrial development of a community than the amount of iron which it requires to meet its demands and the development of civilization is most intimately connected with the growth of the iron and steel industries. There is no article used in the arts or in daily life in the production of which iron, in some form or other, has not been used, and it is impossible to imagine the conditions to which the world would be reduced if the production of iron and steel were to cease or to be seriously curtailed.

Though iron is the most abundant and most widely distributed of the metals, and is very readily reduced from its compounds, it is so difficult to obtain it in a state of purity that pure iron is only a chemical curiosity. Iron combines so readily with most of the other elements that it unites with them at the moment of its liberation and subsequent purification is a matter of extreme difficulty.

Commercial irons sometimes contain more than 99.5 per cent of iron, but the removal of the remaining 0.5 per cent of impurity is very troublesome. Pure iron is white—almost silver white— in color, and has a brilliant lustre.

Iron is an electro-positive metal which combines readily with oxygen, chlorine, sulphur and other negative elements under suitable conditions. It also alloys readily with most metals and dissolves many times its own volume of such gases as hydrogen, nitrogen and carbon monoxide. Iron which is, in the ordinary use of the term, chemically pure, may be obtained in the state of powder by reducing precipitated ferric oxide by means of hydrogen, and then heating in vacuo to remove the residue of hydrogen retained in the metal. This is only a chemical

laboratory method and it is observed, that it involves as the first stage the preparation of a pure iron salt. It forms two series of compounds in which it acts respectively as a divalent and trivalent radical. These compounds are known respectively as ferrous and ferric oxide. According to Carpenter the melting point of pure iron is 1505 degrees Cent. The metal when allowed to cool from its melting point to the ordinary temperature, shows three small, but quite definite arrests in the rate of cooling. Three similar arrests are noted in the rate of heating as the temperature is raised from that of the atmosphere to the melting point. On account of what is known as lag, or molecular inertia the observed points of arrest are in each case somewhat lower if recorded with a falling than with a rising temperature. To make this clearer, suppose we split up those three temperatures into distinct regions. Now as the metal cools from one of those regions into the other, its constitution ought theoretically to change from the theoretical constitution of the region it is leaving to that into which it is entering, but owing to this lag, the transformation which should occur on crossing this boundary may be suppressed partly, by the opposition of the cold. This molecular inertia is a matter of very great importance and to it we are in large part indebted for our power of giving to a given piece of iron or steel a greater variety of different properties by different methods of heat treatment. These methods act chiefly by inducing certain desirable degrees of lag, or by stimulating some reaction which has already lagged, and thus reviving it under favorable conditions.

This is proven beyond the shadow of a doubt in the hardening, tempering and annealing of steel, the chilling and annealing of cast iron and the manufacture of malleable iron castings. Those three points may be taken as being approximately 680, 760 and 870 degrees Cent. The number and position of these points of arrests are, however, altered according to the nature and the proportion of other elements which may be present in the iron. The lowest point of arrest is scarcely perceptible with the purest iron which is obtainable and the highest point is then most distinct. But on adding more and more carbon the highest point is caused to steadily fall,

until with high carbon steels only one point is noted, this is extremely well marked, so much so as to cause the steel, after it has cooled to a dull red heat, to suddenly glow again and increase in length. This phenomenon which was originally observed by Gore, is known as recalescence. This spontaneous absorption or evolution of heat during the heating or cooling of the metal is most advantageously studied with a 6 per cent steel. If a piece of steel of this carbon content be heated to 1000 degrees Cent. and allowed to cool slowly from that temperature and if its rate of cooling be carefully ascertained by means of a pyrometer, it is found that the cooling proceeds at first at a nearly uniformly retarded rate. If it requires say 10 seconds for the metal to cool through the first five degrees and 12 seconds to cool through the next five degrees and so on, the cooling through each range of five degrees being a little slower than the preceding cooling of five degrees. As a matter of fact, all cooling bodies, no matter their nature, generally follow this law. In the case of the steel we are considering, when a certain temperature is reached, in the majority of cases some 650 to 700 degrees Cent. this most interesting and singular phenomenon takes place, the cooling of the metal is momentarily arrested, the pyrometer, for a certain length of time, failing to record any further fall of temperature. Indeed, when the circumstances are favorable, the temperature of the cooling mass actually rises, the metal becomes visibly hotter, it recalesces, at this thermal critical point and this spontaneous glow of the metal is plainly visible if the experiment is carried out in a dark room. It is evident that at this critical point the surrounding atmosphere does not cease to abstract heat from the piece of metal and since its temperature nevertheless remains stationery or even rises, it must be that heat is here spontaneously generated within the metal in amount sufficient to make up, or more than make up, for the heat lost by radiation and conductivity.

Reasons for Evolution of Heat

Three reasons may be given for the evolution of heat at Ar.1: (1) Formation of the carbide, Fe_3C based on the assump-

tion that carbon as such is dissolved in iron; (2) crystallization of the carbide Fe_3C based on the assumption that this carbide is dissolved in iron and that crystallization not implying a change of state may produce heat; and (3) allotropic transformation of the iron present in austenite of eutectoid composition, that is the conversion of a solid solution into an aggregate or ferrite plus cementite.

These critical points of iron really represent ranges of temperature, although for the sake of inconvenience, we call them points.

The only consistent explanation of this unique behavior of iron and steel during cooling is that suggested by Osmond, who advanced the theory that iron is capable of existing in three allotropic modifications, these are known respectively as Alpha, Beta and Gamma. The chemist is familiar with the fact that many of the elements exist in two or more modifications which differ from each other in physical properties, and to some extent also in chemical behavior. To such phenomena the term allotropy is applied.

We ask ourselves the question. How can the same substance exist in different forms? Just as the builder can with the same kind of brick build up various structures, so can Nature with the same kind of atoms build up molecules with very different properties. The term is not applied to the different states of aggregation of a substance—solid, liquid or gaseous. Allotropic transformations are usually accompanied by changes in the interval energy of the substance concerned. Energy is at a higher potential in one allotropic form than in another. Thus carbon exists in three allotropic modifications, the diamond, graphite and amorphous carbon. The diamond may be produced from other varieties of carbon by heat and pressure and it retains a constitution, the breaking up of which absorbs heat. Hence, carbon in the form of diamond evolves less heat when burned than either graphite or charcoal. It has already been noted that any allotropic change is accompanied by an evolution or absorption of heat. On the other hand, there are certain changes which occur in metals, such as those due

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to the effects of work, which cause important alternations in properties, but which are not classed as allotropic. As to exactly where allotropy ends and merely physical difference begins, is largely a matter of definition.

Those critical points are represented by the letters Ar1 on cooling and Ac1 on heating. Suppose we consider the points Ar1 and Ac1 and that will be sufficient to cover the series. The critical points Ar1 and Ac1 do not occur at exactly the same temperature, Ac1 being generally some 25 to 40 degrees higher. It does not follow, however, that these two points are not the opposite phases of the same phenomenon. The fact that the critical point on cooling lags behind the point on heating and vice versa, is evidently a case of hysteresis so often observed in physical phenomena and which implies a resistance of certain bodies to undergo a certain transformation, when theoretially the transformation is due, the delayed transformation finally taking place with added violence. This is vividly depicted in the case of iron, for, just as we can cool water below its freezing point without completely freezing it, thereby rapidly increasing the strength with which the water tends to freeze, so by a relatively rapid cooling we can carry the metal considerably below Ar1 without giving the Ar1 change time to proceed far, strengthening the while the tendency toward this change which keeps kindling more and more till it bursts into a blaze, with such evolution of heat as actually to raise the temperature of the metal by some 10 degrees, in spite of the continued abstraction of heat by the continued cooling of the furnace. The slower the heating and cooling the nearer will the two points approach each other, so that with infinitely slow cooling and heating they would undoubtedly occur at exactly the same temperature. If there remained any doubt as to the points Ac1 and Ar1 representing the opposite phases of the same phenomenon, namely of A being a reversible point, it would suffice to dispel it to consider the fact that in order to induce the retardation Ar1, the metal must first be heated past the point Ac1, and reciprocally the retardation Ac1 cannot take place unless the metal has first been cooled to a point below Ar1.

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To illustrate our point—the melting of ice and the freezing of water are undoubtedly the opposite phases of the same phenomenon, each one undoes the work of the other, and in order to freeze the water we must first melt the ice and likewise to melt the ice the water must first be frozen, one change cannot be induced unless the opposite one has last taken place. Indeed it is possible through very slow and undisturbed cooling to lower the temperature of water below its freezing point before it starts freezing, a clear instance of surfusion and when freezing takes place the temperature of the water rises to its normal freezing point, a clear case of recalescence although deprival of glow.

How Iron Solidifies

According to the allotropic theory iron solidifies in the Gamma condition and if quickly cooled remains in that condition, but if the metal be allowed to cool slowly at about 870 degrees it passes into the Beta form and on further cooling to about 760 degrees it assumes the Alpha condition which is the ordinary soft or normally cooled metal. The arrest at 680 degrees is not connected with any allotropic change, but is due to the separation of the carbon as carbide, which at higher temperature exists in the state of homogeneous mixture, or solid solution, with the iron. But at 680 degrees with slow cooling, the carbide and iron separate, forming alternate layers of the carbide of iron, cementite, and Alpha iron. To this eutectoid structure, the name "pearlite" is applied.

Alpha iron, or alpha ferrite as it is often called, is soft, magnetic, incapable of dissolving carbon, and does not occur in macles, or twin crystals when viewed under the microscope. Beta iron is non-magnetic, the loss of magnetism occurring at 760 degrees, it is almost without action upon carbon, and does not exhibit the power of twinning. Gamma iron readily takes up carbon, especially as the temperature rises. It is stated to be hard, and can be recognized under the microscope by the occurrence of twin crystals. It may be observed in passing that there are many points of similarity between what occurs during the slow or rapid cooling of a silicate fusion, or slag, and the slow

or rapid cooling of a fluid mass of iron containing carbon. In each case the molten substance consists of a homogeneous mixture, or solution, which in either case if rapidly cooled forms a single solid solution; the solid solution is a glass when obtained from silicates, and is hardened steel if produced from iron—carbon alloys. In both cases, also, slow cooling leads to the production of a heterogeneous mixture, in the one series of crystallized silicates, in the other of ferrite with graphite, and more or less pearlite.

Now Gamma iron is said to be hard, Alpha iron soft. If, therefore, Gamma iron be quickly cooled past Ar2 critical point, the passage of the hard Gamma iron to the soft Alpha iron is retarded, the iron is then in an unstable hardened condition, ready on the least provocation to pass into the stable soft Alpha form.

We naturally ask is there any method of helping the passive resistance so that the iron will not readily change from, say, the Gamma to the Alpha modifications at ordinary atmosphere temperatures. It is supposed that the presence of many foreign substances, like carbon, nickel, and manganese, augment the passive resistance so as to render the hard Gamma iron more stable and permanent at low temperatures. On the other hand, the presence of chormium, tungsten, aluminum, silicon, phosphorus, arsenic and sulphur facilitate the passage of hard Beta iron to the soft Alpha form.

The influence of minute traces of foreign substances upon the properties of the metals, either ferrous or non-ferrous, is a most important subject. As a matter of fact a few hundredths of one per cent of sulphur will determine the success or failure of iron and the presence of 0.1 per cent of bismuth in copper lowers its conductivity so much that if copper so contaminated had been alone available, it would have been fatal to the success of the Atlantic cable. Some metallurgists have been loth to accept Osmond's theory, and an unfortunate controversy has taken place on the subject. Arnold, Carpenter and a few others maintain that there is no Ar or Ac2 point, consequently it will be well for us to study very minutely what really takes

place at the respective ranges of temperatures as far as physical properties are concerned before passing our verdict on this particular point.

It is a well known fact that when a substance undergoes an allotropic transformation many of its properties undergo likewise deep and sudden changes at the critical temperatures.

Color, crystallization, dilatation, conductivity both for heat and electricity, strength, ductility, hardness, specific gravity are properties frequently affected as a body passes from one allotropic form to another.

The metal above Ar3 point is contracting, on passing through this point it undergoes suddenly a marked dilatation amounting to over 1-1000 of its length, immediately followed again by a normal contraction. As it cools to the point Ar3, there is but a feeble decrease of its electrical resistance, but as soon as Ar3 is reached it begins abruptly and sharply to decrease, and keeps on doing so until atmosphere temperature is reached. It also crystallizes in the Octrahedra form, and is softer more ductile and weaker in the Gamma condition. Above this point iron possesses the power of dissolving carbon.

Changes are Gradual

Now at the Ar point these changes are more gradual than at the other critical point and the logical explanation is based on the ground that Beta and Alpha iron are isomorphous, that is capable of forming solid solutions and that therefore the passage of one variety into the other must necessarily be gradual. Of course it is a very difficult matter to differentiate between Alpha and Beta iron, as their crystallization and other properties are almost identical. However, both schools of metallurgists, whether allotropists or carbonists are in agreement as to the fact that carbon is an essential constituent in steel and cast iron and that the properties of the material are dependent upon the percentage and form of occurrence of this carbon. But while the carbonists appear to regard the solution of carbon in iron at various temperatures as being due merely to laws such as govern the solubility of substances in common solvents, the

allotropists contend that that state of the carbon is largely governed by the formation and properties of the allotropic modifications of iron. Thus, while all agree that the chief determining cause of the variation in properties of the various members of the iron carbon series is the amount and condition of the carbon, those that accept the allotropic theory further contend that the condition of this carbon is itself fixed by the allotropic condition of the iron with which it occurs. A considerable proportion of the pig iron which is annually produced is used by the iron founder for the purposes of his art. It has sometimes been suggested that cast iron was in danger of being superseded by steel or wrought iron and though it has been generally abandoned for construction purposes, so many other applications have been found for this material that the art of the founder is in no danger of extinction or even of serious diminution. Cast iron is the cheapest and most abundant form in which the metal is met with in commerce. It is fusible at a temperature which can be readily attained, and as it receives remarkably exact and clean impressions of a mold, it can be cheaply produced even in very intricate forms and being protected by a skin, cast iron resists atmospheric influences better than either wrought iron and steel, while for the wearing surfaces of machinery nothing is superior to cast iron so long as sufficient area is provided. Iron castings can be prepared to meet a pressing emergency while their fine surfaces, sharp edges and pleasing appearance recommend them for general use. Cast iron is a complex aggregation which includes elements and compounds and supplies examples both of chemical combination and of mechanical mixtures. In fact it is a heterogeneous mixture. The elements which are regularly present in cast irons may be divided into three classes according as to whether they are essential fairly constant, or variable in amount. In the first class carbon stands alone. It is an essential constituent of all cast iron, since with less than 2 per cent carbon, the characteristic properties of cast iron are not obtained. In the second class are included those which are fairly constant, in all grades of pig iron made from a particular ore mixture. These elements are phosphorus and manganese. The elements

of the third class are those which vary with conditions and circumstances around the blast furnace. These elements are silicon and sulphur. As we are all more or less well posted as far as silicon and carbon are concerned, I will leave those two elements severely alone and confine my attention to the consideration in detail of the influence and state of combination of the elements, sulphur, phosphorus, manganese, aluminum and copper and it will be more advantageous if we consider them not as entities but as compounds with other elements.

Influence of Sulphur

It is universally known that manganese and sulphur have great reciprocal affinity, so that when brought together at a high temperature they combine chemically with each other to form manganese sulphide. From their respective atomic weights it is noted that approximately 2½ parts of sulphide is produced for each part of sulphur and it occurs in rounded areas. Manganese sulphide has a melting point superior to that of iron, it solidifies first and the bulk rising to the top of the bath passes off in the slag. In cast iron there is usually not sufficient manganese present to ensure the removal of the sulphur and any that is left over after the satisfying of the manganese, gradually clings to the iron forming FeS.

This sulphide exhibits a marked tendency to form continuous envelopes or membranes surrounding each grain of pearlite. These membranes being weak and brittle impart weakness and brittleness to the metal. The red shortness caused by sulphur is due to the absence of a sufficient amount of manganese to form MnS which reduces the melting point, hence we find FeS present in the metal. Owing to the low melting point of the latter, we find at a high temperature the melting of this eutectic destroys the cohesion between the grains of the metal. It also induces the formation of thick cell walls and separates the crystalline grains one from the other, hence lowering the tenacity.

Owing to its intercrystalline weakness 1 per cent sulphur arranged as a mesh of iron sulphide will entirely destroy the ductility of the iron, reducing the ultimate stress from 20 to

even 2 tons per square inch. In summarizing we find that sulphide of iron is deadly in its effects while sulphide of manganese is comparatively harmless. The above effects are due to the fusibility, the high contraction coefficient and the tendency of sulphide of iron to form cell walls or enveloping membranes surrounding cells of ferrite whilst sulphide of manganese is much less fusible, segregates whilst the iron is at a high temperature, and so collects into rough globules and very seldom into meshes. Then again if the sulphur is in excess over and above what can be taken up by the manganese we may find it combining with the oxygen or hydrogen of the air to form sulphur dioxide or sulphuretted hydrogen. Now the latter combinations may have some hand in the formation of slip bands which are a source of weakness to the metal. The lines are not actual cracks in the surface, but rather slips along the cleavage planes of the crystals. These slipbands can be identified when under a progressively augmented strain, rupture taking place, which develops into cracks, not at the crystal boundaries, but through the crystals themselves. The latter theory is one made in Detroit, but nevertheless I am convinced that a great deal of the trouble lies here. Not only so but we can have ferrous sulphide in two forms, one being a little harder than the other so that when all is said and done the modern iron founder has a great deal to contend with even with this element alone. The transition from the one to the other is accompanied by considerable dilation.

Phosphorus

Of all impurities usually present, practical experience has established the fact that this element is the one that most prejudicially influences the physical properties of the metal by producing brittleness under shock and generally by the phosphorus being evolved as phospheretted hydrogen, which is more or less evenly distributed throughout the metal. The phosphorus, however, which is usually present in cast iron exists as a phosphide of iron or Fe_3P or it may be present as a phosphide of manganese. A common cause of porosity in castings is segregation, or the collection together of impurities in spots.

This segregation is the greater, the greater amount of phosphorus. The latter increases segregation by making a fluid eutectic, which does not solidify until after the remainder of the casting and then runs into that part of the metal having the loosest mixture. These localities are very porous and sometimes they are so extremely hard that no tool will cut them. It also increases the size of the crystals and causes expansion during solidification. It decreases shrinkage, because it contributes to the fluidity of the metal and gives a better opportunity for the carbon to separate. When the silicon is high and the phosphorus relatively high the latter has the tendency to lengthen the period of solidification. That is to say, it makes the iron pass through a somewhat mushy stage of solidification and this stage may last for several minutes. The flakes of graphite will be larger, consequently the iron will be weaker. According to Fettwein the proportion of carbon that iron is capable of dissolving is diminished by phosphorus. This phosphide of iron exists as solid solution or as a eutectic. Beyond a certain percentage the excess of phosphide separates out of the mass to form cell walls of Fe_3P around the original cell-like grains and the enclosures are so irregularly shaped that one has no difficulty in identifying them under the microscope. As a matter of fact this separation of phosphide is analogus to the separation of Fe_3C from metal which contains more than 0.9 per cent C. If an iron which contains phosphorus be heated in a neutral atmosphere to a temperature of over 900 Cent., globules of iron rich in phosphorus gradually exude from the mass, leaving the original material honeycombed in consequence, hence, phosphorus irons are not suitable for the production of articles which are exposed to high temperatures. From a large number of tests it has been found that phosphorus exerts no influence on the carbon. It does, however, lessen the tendency to form blowholes and causes the metal to remain fluid longer when melted, but it does not make the molted metal so limpid as has been supposed. We don't require usually to search for phosphorus, as most iron contains more than is needed and great

care should be taken to keep it within limits, as it is so easily to over-balance its advantageous effects by its detrimental symptoms.

Manganese

I have discussed this element pretty fully with sulphur, hence there is not much more to add regarding same. It acts very much like sulphur and phosphorus, in aiding segregation and we usually find when these three elements are present in large quantity segregation is always excessive, with the ultimate result we have porosity. If manganese is present in certain proportions it is a magnificent deoxidizer, consequently we have the problem of occlusion of gases partially solved. The influence of manganese in opposing the formation of graphitic carbon we all know; like sulphur it is a hardener, its presence in large proportions increases the difficulty of machining castings, so here again we have a case of very judicious mixing before we can really strike its beneficial effect. It augments the passive resistance, so as to render the hard Gamma iron more stable and permanent at low temperatures.

Aluminum

Although this element does not appear to combine as energetically with iron as with some other non-ferrous elements, yet the affinity between these two elements is sufficient to cause their combination in all proportions. The useful alloys, however, are confined to those containing a small amount of aluminum. Iron containing this element has been produced considerably in British practice owing to the fact that we have in Antrim an ore containing a large quantity of Aluminum, replacing ferric oxide. This ore is practically free from phosphorous, hence, the high standard of excellency of Scotch Foundry iron. The presence of aluminum makes the iron more fluid, makes hard iron softer, frees castings from hard spots and blow-holes and lessens the tendency of the metal to chill, although a small trace of aluminum has a very marked effect in rendering cast iron graphitic. It is remarkable that in the purer classes of pig iron any further addition of this element,

beyond 1 per cent, causes the proportion of graphite to diminish until with about 7.5 per cent the carbon of white iron is retained in its original combined condition. At the present time we have no true chemical formula representing the peculiar characteristics of this element when used as a deoxidizer. Some years ago a paper was read before the Iron and Steel Institute of Middlesborough pertaining to this element and it was pointed out that it had both endothermic and exothermic reaction. When we add our metal to aluminum in the ladle a convection current forms of alumina, which acts as a forerunner as the metallic aluminum is being dissiminated throughout the metal and this is accompanied by an absorption of heat. When the alumina comes to the surface we have decomposition taking place—the oxygen escaping and a portion of the metallic aluminum re-entering the bath with the evolution of heat. This goes on until all the aluminum has been used up and as we have no idea of what quantity of deleterious occluded gases we are carrying it is very seldom all those gases are taken off. The effect appears magical and out of all proportion to the small amount used, but it is a question of dexterity of judgment on the part of the superintendent of how much aluminum to add to give him advantageous results. It increases the tenacity of the metal by hindering the formation of blow holes.

Copper

This element is not unfrequently present in small quanties in cast iron. When present to the extent of 0.5 to 0.65 per cent it encourages closeness of grain and its presence must be regarded as more beneficial than otherwise. Sometimes the metallurgist has to face the incontrovertible fact that steel which has safely passed all the mechanical tests occasionally develop an extraordinary tendency to become brittle and break under stresses far below the elastic limit of the metal. The disease may not be due to any alternation in the crystalline form of the metal. In many cases the source of weakness is the joints between the crystalline grains or as Stead calls it, intercrystalline weakness. The latter is really imperfect union

of the crystalline grains. This is particularly marked in phosphoric iron. The crystal grains on cooling contract unequally and tend either to draw the grains away from each other or to leave the mass in a state of unnatural tension. This intergranular weakness resembles the weakness of a brick building with faulty mortar. Suppose the mortar has been prepared from lime containing carbonic oxide, then we would have a useless mass. Then we have a condition of things which resembles copper and phosphorus. If the phosphorus is present as cupreous phosphate instead of as a phosphide of iron, we would not have the metal fracturing through the center of this brittle envelope. As an example, pearlite cells bound together by thick cementite walls are liable to rupture, because the co-efficient of contraction of the cementite cell walls is greater than the cell contents and this is where copper has its beneficial effect by bringing those two conditions to an equilibrium basis, so that the mass instead of being feebly held together has a strong tenacious hold.

Copper was formerly looked upon with disfavor by certain metallurgical schools, but from experiments carried out on a practical scale by certain plants, we have entirely disproved the notion held by inspecting engineers that this is a deleterious element.

Green Sand Cores

By James Mulvey, Troy, N. Y.

On account of the increased production due to improvements made in molding machinery, I know many foundrymen believe that core-room practice has not kept pace with the molding end of the business. Of late years we have had the benefit of several ingenious inventions in core machines which have enabled us to produce cores at a fraction of the cost of hand made ones of the same character, but I still think we have not kept up with the molding department.

This paper is written to draw the attention of our foundrymen to the possibilities of green sand cores. Six years of constant contact with green sand cores gives me some right to speak on this question. The temptation is strong to stray from the text and take up the dry sand core question in connection with the green sand, but the result would be a volume instead of a small paper, although some reference to this matter may be necessary for comparison.

The green sand core to my mind has been neglected or has not had the attention or study that it deserves, and very few give it a passing thought. I find there are hardly any castings of regular running work which require cores that with careful study you cannot use green sand cores on to some extent. There are many concerns who are at present making castings of light weight, and some that weigh 800 pounds each with green sand cores.

The castings are of various shapes and sizes, and include tees, pipe fittings, or in fact most any kind of work that is standard. The advantages of green sand cores are numerous and while I know that I cannot do the subject justice, I will try and give you some ideas.

I have not seen any molding machine on which you can use green sand cores, that can be kept away from the coremaker. Also you require very little storage room, or in fact no core room, as I will explain later. When the jolt machine

came on the market and engineers said: "Make your core rooms as large as possible, and then some." I consider this good advice only where dry sand cores are used. It is not necessary for me to ask those foundry superintendents that have a large shop with plenty of floor space if they find it hard to pay for that space during a slack year, or in times of depression, hence my argument for the study of green sand cores.

Green sand cores are always ready for the molder. You can have them just as fast as you can make the molds, and much faster. There is little mixing of sand and no baking. The caving in, shaking out the cores, and other economics over the dry sand method will cover the cost of your rigging.

The sand is used from the molders' floors, and the small amount of facing that is used will keep the molding sand in the proper condition. The sand should be selected according to the weight of the casting. A fine grade should be used for small work up to 10 pounds in weight, and No. 3 or No. 4 open sand for work up to 800 pounds. The sand used for the various work can be taken from the molders' floors, as a sand that is suitable for the outside of a casting, you will find, with proper care, will be equally suitable for the inside.

Great care should be taken in venting the cores. The vents should be large and kept open to let the gas off freely; this will prevent cutting and other troubles.

The shrinkage of the castings is more uniform with green sand than with dry sand cores, and you can depend on your castings coming almost true to the required size. Some foundrymen will appreciate this feature, especially those who make lock or screw joints or fittings.

Valuable for Brass Work

Green sand cores are valuable in casting yellow brass, the common red metal, or in fact any of the bronzes of the 88-10-2 type, as the dangers of porous castings are greatly reduced. Also where the work must stand a hydraulic test, or where it is dipped, they will prevent troublesome spotting out. The cores should be built up on arbors and if the shape of the castings permit the parts of the arbor must be built

with a tongue and groove and dovetailed together. The tongue and groove can be cast on the arbor without any machining and should be made so they will drop in without driving; they should also be snug enough so they are not loose. You will find that the up-keep of the arbors is very small.

In casting the arbors, the pattern should be made with lifting holes or handles so you can lift the small cores from the core box; but the large cores that are too heavy to handle by hand, should be provided with trunnions so they can be handled by the crane.

The large cores that are handled with a crane should be made on a drop machine or table, so the core box can be drawn away from the core. This is a much better method than drawing the core from the box and will insure better and almost perfect cores. Some core boxes can be made with hinged joints and the arbor should be made to fit the drag half of the box which carries the sand; the cope half is flopped over on the drag and then rolled back in the same position and the core removed.

My object in calling your attention to the rolling back operation is to show that little motion and no time is lost in digging out core plates, beams or clamps to turn over with the core. After your cope half is rolled back and your core lifted or drawn from the box, it is ready for the mold and the core box ready for the next core. The core boxes should be well cared for and kept well waxed.

In cleaning the castings made with green sand cores, there should be no hand work. The cleaning can be done either with a sand blast or with tumbling mills. The saving here alone is noteworthy.

Practically no chipping is necessary as the cores can be made very close without danger of crushing, and there are no large fins such as you get with dry sand. The pasting is entirely eliminated. Make your prints deep so the casting will not come too close to the flask and make your arbor close to your core box. Also make your flasks heavy enough to stand up on jolt or squeezer machines.

XUM

Memorandum on the Preparation of Standard Specifications for Cast Iron for International Export Use

By Dr. Richard Moldenke, Watchung, N. J.

It will be of particular interest to the members of the American Foundrymen's Association to know that the pioneer work on standard specifications for pig iron, cast iron and special castings, accomplished by its members and the Association as a whole, is now in a fair way to become of international importance.

It will be remembered that the extensive researches on the Cast Iron Test Bar, executed by a special committee of the Association, served as a basis of the subsequent standard specifications of the American Society for Testing Materials, of the Cast Iron Committee of which Society the A. F. A. Committee formed the nucleus.

The work along this line brought out in America stimulated the foundrymen of Germany, and the result was a German standard set of specifications for cast iron, etc. In England, the third of the great producing countries, things have not gone very fast and even today there is little agreement on the subject, in fact a disposition to mark time. The other, smaller producing countries, have done practically nothing to advance the art of testing cast iron, investigations by individual experts being rather along the line of scientific interest than practical accomplishment.

With definite standards set up for this country, it was but natural that attention should be directed to an expansion outside of our borders, to facilitate trade between the producing and consuming countries. As early as 1901, at the Buda Pesth Congress of the International Association for Testing Materials, the question of International Specifications for the Materials of Construction was strongly urged upon that body by Prof.

Howe, Mr. Walter Wood, and the writer. It was, however, difficult to interest men who were for the most part government councillors and dignitaries, though they were fully alive to the desirability of such a procedure, as the "resolutions" of each succeeding Congress plainly indicate.

When finally it was seen that little headway was possible in view of the different methods employed in making finished products from the raw material available in the several countries, the idea of preparing international standards applicable for each country was abandoned, and for this was substituted the preparation of international standards intended for export purposes only. In other words, in bidding upon an inquiry emanating from a non-producing country, such as South America, Africa, etc., every producing nation would, through the adoption of international standard specifications for export. be placed on the same footing, and the country best situated for delivery at the lowest figure would win out. Without such a safeguard for the buyer, he would be unable to select to his best advantage, and the tendency would be toward dumping inferior material abroad.

With, however, such an international agreement, there would be a steady improvement in the quality of exports, which in turn would react in a highly beneficial way upon the domestic situation.

In order to try for a definite advance of this idea for cast iron and its products, two of the A. F. A. members, Mr. Walter Wood and the writer, as the American members of the International Committee on Cast Iron, went abroad last fall and after considerable work with the individual members of the Committee from Germany and England, succeeded in getting a Committee meeting in Brussels, at which definite proposals for pig iron, cast iron pipe and an international test bar were prepared by the German and American members—the English dissenting in part—and presented to the Council of the International Association for Testing Materials, to be in turn presented by the Council before the St. Petersburg Congress to be held in 1915.

Before this action was brought about at Brussels it was necessary to visit many prominent men in Germany, Austria, Italy, France, Belgium and Great Britain, to get their views and interest them in the work. Happily this was not difficult as they were all impressed with the honesty of purpose of the American members, who constantly brought out the fact that the work was intended for the benefit of the world and not an individual nation.

As stated above, the English members finally dissented from the proposals made by the majority of the Committee in the following respects: The standard specifications for the purchase of pig iron were rejected entirely, and in place of them a set suitable for English conditions advanced. There need only be said that with a classification of pig iron into three grades, each allowing the furnace a leeway of an entire per cent of silicon, allowing the furnace to ship what phosphorus it pleases so long as it is not above 1.75 per cent. A maximum of sulphur of 0.05, 0.08 and 0.12 for the three grades in question, and an allowable variation of manganese of from 0.40 to 1.00. With such a classification, if it were seriously considered by foundrymen, they might just as well go out of business. Presumably the British Foundrymen's Association will be duly heard from on this subject.

On the International Test Bar our English friends are more agreeable, there being little information available on the subject in their country. So while they have reserved their decision, they are not unfriendly to the proposal.

Parenthetically it may be of interest to find the reason why no amount of work made in any one country seems to be considered in other countries in studying the properties of cast iron so far as it affects the adoption of a standard test bar. The report of the A. F. A. Committee on testing cast iron was based upon the preparation of several tons of test bars of every size and shape and in green and dry sand. This work, as an advance upon the elaborate work of other investigators, should surely have been sufficient to other countries, unless these wished to make further improvements in

the light of advanced practice. However, such is evidently not the case, and every country seems to want to get its own experience in this direction, even if it takes years to do it.

Finally on the question of cast iron pipe, the English manufacturers were agreeable, but the English engineers considered the specifications proposed not sufficiently strict.

The situation is then that the proposals are published for a full discussion and trial previous to the St. Petersburg Congress, at which time it is hoped that the first standard specifications that are international and intended for export may be formally adopted.

The matter of pig iron specifications is of further interest. It will be recalled that the American standard specifications eliminate all grade numbers and are based entirely on the analysis of the iron. The purchaser can, therefore, call for a given percentage of silicon, manganese, phosphorus, sulphur, and if desired total carbon. On the part of the furnaces there is provided that a lee-way of 0.25 either way from the specified silicon shall be allowable in delivery. Sulphur and phosphorus shall be maxima, and manganese has an allowance of 0.20 either way. In the case of the International Specifications the scope for selection by the purchaser has been considerably extended, so that pig iron for malleable and, in a way, for steel casting purposes can be selected, though carbon has been eliminated.

The point of special interest, however, is the undertaking to prepare international standards for sampling and analysis of the iron. Here a special commission, adjunct to the committee in question, has been appointed, the American representative being Dr. Hillebrand, of the United States Bureau of Standards. The German representative is Dr. Corlies, chief of the Krupp Laboratories. The English representatives are Messrs. Stead and Harbord, both chemists of international reputation.

Dr. Hillebrand has prepared American proposals for the correct sampling of pig iron as well as the test bar representing castings. Also alternate methods for the analysis of these

carefully prepared samples, and this American proposal (by request of the committee chairman, Councillor Bruegmann) is now under discussion for presentation in the same way as the actual specifications. The proposed standard methods are practically those of the A. F. A. committee on this subject, which committee has also been drawn into consultation on the methods of sampling proposed.

Thus there may be said to be a distinct advance achieved. In addition to the original trip abroad by the two members of the International Committee, the writer had to make another journey a few months ago to Turin, Italy, in the interest of this work, and every indication points to a speedy and successful accomplishment of the object in view.

The writer would strongly urge our Americans interested in the production of pig iron, pipe and general castings, suitable for export orders, to attend the St. Petersburg Congress in August, 1915. They will be welcomed by our European friends, have a delightful visit, and in addition help impress those who are luke-warm, so that much good will be accomplished. Any information as to the trip will be gladly given on request.

Appended herewith are the Committee proposals, accepted by the Council of the International Association for Testing Materials, for promulgation, study and trial, and subsequent action by the St. Petersburg Congress.

APPENDIX A

Proposals for International Export Specifications for Pig Iron

(Adopted at Brussels Meeting, December 5, 1913.)

1. It is proposed that for international trading purposes in pig iron, the analysis be taken as the basis, inasmuch as the value depends upon its content.

2. The following specifications for pig iron are recommended where the customary trade designations are insufficient (see tables below). For silicon a variation of 0.25 from analysis asked for, either way, shall be allowable. For sulphur and phosphorus the maxima given shall govern. For manganese a variation of 0.20 either way shall be allowable.

SILICON[1]

Per cent.	Code.
0.50	La
0.75	LaX
1.00	Le
1.25	LeX
1.50	Li
1.75	LiX
2.00	Lo
2.25	LoX
2.50	Lu
2.75	LuX
3.00	Ly
3.25	LyX
3.50	Lh
3.75	LhX

[1]Variation 0.25 either way allowable.

SULPHUR

Maximum Per cent.	Code.
0.02	Sa
0.03	Se
0.04	Si
0.05	So
0.06	Su
0.07	Sy
0.08	Sh

PHOSPHORUS

Maximum Per cent.	Code.
0.050	P
0.100	Pa
0.250	Pe
0.500	Pi
0.750	Po
1.000	Pu
1.500	Py
2.000	Ph

MANGANESE[1]

Per cent.	Code.
0.20	Ma
0.40	Me
0.60	Mi
0.80	Mo
1.00	Mu
1.25	My
1.50	Mh

[1]Variation 0.20 either way allowable.

It was resolved that the code words above given are to be specially recommended as most useful for international commerce in pig iron.

3. That the Council of the International Association for Testing Materials be requested to appoint a standing committee of chemists who shall draw up international standard methods of sampling and analysis of pig iron; and that the Council ask the Verein deutscher Eisenhuttenleute, the Engineering Standards Committee, and the American Society for Testing Materials, to delegate suitable members to serve on this committee.

APPENDIX B

Proposals for International Export Specifications for the Cast Iron Test Bar

(Adopted at Brussels Meeting, December 5, 1913.)

1. In order to obtain a reasonable uniform test bar (arbitration bar) for judging the qualities of iron poured into castings with reference to existing systems of measurement, a round bar shall be selected for testing transversely on supports 18 in. apart (45 cm.). The diameter of this bar shall be 1.2 in. (30 mm.), the relation of length to diameter being 15 to 1 as nearly as may be.

2. The bars shall be cast in dry sand molds, vertically and with top pour. They shall be cast 20 in. (50 cm.) long, and be rounded at the bottom. The load in testing shall not be applied faster than three seconds for every hundredth part of the diameter. For every specification mixture two molds with three test bars each shall be cast, the bars to be cold before removal from the molds which should have attained the shop temperature before pouring. The bars shall be brushed clean and not rumbled.

APPENDIX C

Proposals for International Specifications for Cast Iron Pipe and Fittings

Note.—All measurements shall be stated in English and metric figures; pressures in pounds and atmospheres.

(Adopted at Brussels Meeting, December 5, 1913.)

Description of Pipe.

Section 1. The pipe shall be made with socket and spigot joints, or with flanges, and shall accurately conform to the dimensions given in the tables. They shall be straight and true cylinders with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter.

When the length for a pipe is stated it is understood to be at least the "laying length".

Whenever pipe of thicker section are required, the increase of thickness may be obtained by reducing the bore, so as to maintain the outside diameter constant.

These specifications also apply to turned and bored pipe.

Turned and bored pipe shall be machined accurately so as to make water-tight joints. When the pipe are driven together the spigots shall come within $\frac{5}{8}$ in. of the shoulder of the socket.

Flanged pipe shall be faced on wide strips, straight across, or with check joints, as ordered. Bolt holes may be drilled or cored.

Allowable Variation in Pipe and Sockets.

Section 2. The diameter of the spigot ends and sockets of the pipe shall not vary from the standard dimensions by more than the following amounts:

0.12	in.	for	pipe	16	in.	or less	in	diameter
0.16	"	"	"	18	"	—24	in.	"
0.20	"	"	"	30	"	—42	"	"
0.24	"	"	"	44	"	—48	"	"
0.30	"	"	"	54	"	—61	"	"

ALLOWABLE VARIATION IN THICKNESS.

SECTION 3. For pipe the standard thickness of which is less than 1 in., the thickness of the metal in the body of the pipe shall not be 0.12 in. less than the standard thickness; for pipe thicker than 1 in., this deviation shall not exceed 0.15 in., except that for spaces not exceeding 8 in. in length in any direction an additional variation of 0.02 in. shall be permitted.

These variations refer to castings from standard patterns.

For fittings a variation of 25 per cent greater than allowed for straight pipe shall be permitted.

CUTTING SPIGOTS.

SECTION 4. All pipe cast socket down must be made with a sink head on the spigot end, to be cut off in a lathe, leaving the pipe of the standard "laying length". It shall be permissible to supply 5 per cent of the total order of pipe in lengths not over 10 per cent shorter than the standard length.

FITTINGS.

SECTION 5. Fittings shall be made in accordance with dimensions given in the tables provided.

The internal diameters of the sockets and external diameters of the spigots shall not vary from the standard dimensions by more than the following amounts:

0.12	in.	for	pipe	16	in.	or less	in diameter
0.16	"	"	"	18	"	—24 in.	"
0.20	"	"	"	30	"	—42 in.	"
0.24	"	"	"	44	"	—48 in.	"
0.30	"	"	"	54	"	—60 in.	"

These variations apply only to fittings made from standard patterns.

MARKING.

SECTION 6. The inspector shall mark each pipe with its class and number, also his initials, showing its acceptance. The weight shall be conspicuously painted in white on each pipe and fitting after the coating has become hard.

ALLOWABLE PERCENTAGE OF VARIATION IN WEIGHT.

SECTION 7. No pipe shall be accepted the weight of which is more than 5 per cent less than the standard weight. No excess above the standard weight of more than 5 per cent shall be paid for.

When pipe are cast to order, the total weight to be paid for under the contract shall not exceed the total of the standard weights of the whole order by more than 2 per cent.

No fittings need be accepted which are under the standard weight by more than 10 per cent for pipes 12 in. or less in diameter, and 8 per cent for larger sizes, except that curves, Y-pieces and breeches pipe may be 12 per cent below the standard weight; and no excess above the standard weight of more than the above percentages for the several sizes will be paid for.

These variations apply only to castings made from standard patterns.

Quality of Iron.

Section 8. All pipes and fittings shall be made of cast iron of good quality and of such character that the metal in the castings shall be strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting.

These specifications refer to iron remelted in the cupola, and not to metal taken direct from the blast furnace, or mixed iron, for the use of which special sanction must first be obtained and suitable regulations agreed upon.

Tests of Materials.

Section 9. Of the metal used, specimen bars, 26 in. long by 2 in. wide and 1 in. thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the founder shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 in. apart, and loaded in the center, shall support a load of 2,000 lb., and show a deflection of at least 0.30 in. before breaking. The founder shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from those given above, a proper allowance therefor shall be made in the results of the tests.

Casting of Pipe.

Section 10. The straight pipe shall be cast in dry sand molds in a vertical position. All pipe shall be cast with the socket end down unless otherwise approved.

The pipe shall not be stripped or taken from the mold while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Quality of Castings.

Section 11. The pipes and fittings shall be smooth, free from scales, lumps, blisters and holes, and defects of every nature which unfit them for use.

No plugging or filling will be allowed.

No pipes or fittings shall be rejected for faults which do not affect their usefulness for the work for which they are intended.

Cleaning and Inspection.

Section 12. All pipes and fittings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust and approved in these respects by the engineer immediately before being dipped.

Coating.

Section 13. Every pipe and fitting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle or with any tendency to scale off.

Each casting shall be heated to a temperature of 100 degrees Cent. immediately before it is dipped. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath a sufficient time for proper coating.

The varnish shall be heated to a temperature of 300 degrees Fahr. and shall be maintained at this temperature during the time the casting is immersed.

Fresh varnish or oil shall be added when necessary to keep the mixture at the proper consistency. After being coated, the pipe shall be carefully drained of any surplus. Fittings shall be coated in the same manner as pipe unless impracticable because of dimensions.

Hydrostatic Test.

Section 14. The straight pipes shall be subjected to proof by hydrostatic pressure, and, if required by the engineer, shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipes shall be subjected are as follows:

	20-in. diam. and larger, lb. per sq. in	Less than 20-in. diam., lb. per sq. in.
Class A pipe	150	300
Class B pipe	200	300
Class C pipe	250	300
Class D pipe	300	300

Fittings shall be hydrostatically tested when specifically required by special agreement, which shall state the amount of pressure that shall be applied.

Weighing.

Section 15. The pipes and fittings shall be weighed at the foundry for payment under the supervision of the engineer, who may at any time require the examination and certification of the accuracy of the weighing apparatus. Castings requiring machining shall be paid for at "casting weight". Tenders shall be submitted and final settlements made on the basis of weight.

Founder to Furnish Labor and Material.

Section 16. The founder shall provide all tools, testing machines, materials and labor necessary for the required testing, inspection and weighing at the foundry of the pipe and fittings. Should the purchaser have no inspector at the works, the founder shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the result of the tests upon the test bars.

POWER OF INSPECTOR.

SECTION 17. The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting and coating of the pipes and fittings. The forms, sizes, uniformity and condition of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject any pipe or other casting which is not in conformity with the specifications or drawings.

The inspector shall be fully competent to properly perform his duties, and must not retard the work of the pipe foundry by any neglect on his part, and if considered unfair and unreasonable in his inspection, the founder shall have the right to demand his removal and a competent and reasonable inspector placed on the work.

No pipes or fittings shall be rejected for faults which do not affect their usefulness for the work for which they are intended.

INSPECTOR TO REPORT.

SECTION 18. The inspector at the foundry shall report daily to the foundry office all pipe fittings rejected, with the causes for rejection. A copy of the inspector's certificate to the engineer shall be simultaneously furnished the founder.

CASTINGS TO BE DELIVERED SOUND AND PERFECT.

SECTION 19. All pipe and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the founder of any of his obligations in this respect, and any defective pipe or other castings which may have passed the inspector at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the founder shall not be held liable for pipe and fittings found to be cracked after they have been accepted at the agreed point of delivery.

The manufacturer shall not be held responsible for any expenses or damages incurred in handling or using the castings. Any pipe or standard fitting that proves defective shall—when

requested—be replaced by the maker, the measure of damage not to exceed the value of the casting. The manufacturer shall have the right to call for the defective casting to be returned before any allowance is demanded.

DEFINITION OF "ENGINEER".

SECTION 20. Wherever the word "engineer" is used herein, it shall be understood to refer to the engineer or inspector acting for the purchaser and to his properly authorized agents, limited by the particular duties entrusted to them.

SPECIFICATIONS.

SECTION 21. The details of these specifications apply only to castings made from standard patterns. Any different or "special castings" ordered shall be in all regards subject to special agreement between buyer and seller.

DISPUTES.

SECTION 22. In the case of any disagreement upon the interpretation of any point arising out of these specifications, the matter may be referred by mutual agreement to an independent third party for decision.

APPENDIX D

Proposal of the English Members of Committee 1 (*b*) on International Export Specifications for Pig Iron

Grade	Silicon, per cent.	Sulphur, maximum, per cent.	Phosphorus, maximum, per cent.	Manganese, per cent
1	2.5-3.5	0.05	1.75	0.4-1.0
2	2.0-3.0	0.08	1.75	0.4-1.0
3	1.5-2.5	0.12	1.75	0.4-1.0

Discussion of International Specifications

MR. D. P. HOPKINS:—I have read Dr. Moldenke's paper. I am with the U. S. Cast Iron Pipe & Foundry Co. and just want to take a moment of your time. If you will turn to page 379, you will find these words, "Finally, on the question of cast iron pipe, the English manufacturers were agreeable, but the English engineers considered the specifications proposed not sufficiently strict." I would like to read you just two paragraphs from a letter to us from one of the largest manufacturers of cast iron pipe in Great Britain. The view of all the British vertical cast pipe foundries is that the specifications that Mr. Walter Wood and Dr. Richard Moldenke submitted at the last conference is not acceptable to them. It may be of interest to know that at a meeting of the British pipe makers held on June 19, 1914, it was decided to formally advise the St. Petersburg meeting that the adoption of the proposed specifications was opposed by the British pipe foundries. Going back to the proposed specifications for pipe for export, there is just one point I want to call your attention to, which is entirely different and entirely contrary to the specifications which we are now working under in this country, both those of the American Water Works Association and the New England Water Works Association. This is the third clause in Section 1: "Whenever pipes of thicker section are required, the increase of thickness may be obtained by reducing the bore, so as to maintain the outside diameter constant". Different classes of pipe under our specifications are made from different diameter patterns, and we certainly trust that nothing will be done to depart from that practice, as we do not want to be put to the expense of carrying additional equipment in order to meet that part of the specification.

MR. ALEXANDER T. DRYSDALE:—Regarding the part of Mr. D. P. Hopkins' criticism, where he objects to increasing the thickness of pipe by decreasing the size of the bore. This would, in many cases, necessitate the carrying of two or more sets of core bars, and would be a hardship on any pipe company. A better way for changing the thickness is

as described in clauses 3 and 4 of section 1 of the American Water Works association standard specifications. These specifications were worked out by the United States Cast Iron Pipe & Foundry Co. and I think were adopted almost verbatim by the American Water Works association. Likewise they have been in use for several years and I think represent the best modern practice.

DR. RICHARD MOLDENKE:—In replying to criticisms regarding the proposed Standard Specifications for cast iron pipe for export trade, it should be borne in mind that in their preparation the regular national standard specifications of the United States, Great Britain and Germany were carefully compared, and the best selected from each. So far as the American position is concerned, it may be said in contradiction to the criticisms made as to a standard measurement for each diameter of pipe, that the following facts present themselves:

First:—The engineers, representing the purchasing power, demand that the external diameters remain constant.

Second:—The American Water Works Association is insisting upon this provision in the new specifications it is discussing.

Foreign engineers are insisting on similar practice, and American manufacturers will therefore eventually have to adopt whatever the American Water Works association calls for and what is the practice abroad. Hence, any criticisms of American manufacturers as to the adoption of the external diameter remaining constant will avail nothing, for the wishes of the engineers will prevail.

Third:—The manufacturers, indeed, have already met the views of the engineers half way, as shown by the standard specifications for cast iron pipe of the American Society for Testing Materials. The four classes of pipe stated in these specifications have been reached by taking two external standard dimensions, and two different sizes of internal diameters for each, thus making classes A, B, C and D.

As to the European end there is this to say—The proposed international standards were duly submitted to the

German, Belgian and French pipe manufacturers for approval, after they had been carefully gone over by the representative of the British pipe interests. All the nations in question, while submitting minor points for adjustment, approved the draft as submitted to this association, and it is now up for discussion, trial and final adoption, whenever the European situation so permits.

It should be further stated that the English engineers' committee has not agreed to these specifications, claiming that for large and varied problems that often come to the attention of the Great George street engineers, the proposed specifications are not as precise and rigid as circumstances might make necessary.

As a consequence of the above, the British pipe manufacturers have not officially agreed to the specifications, as they are dependent upon the engineers for their sales. Yet, as stated, their representative at the Brussels meeting was most active and thorough in preparing the proposals.

It must not be overlooked that these standard specifications for export trade are intended for the average buyer, and are so designed that he may rely upon getting good workmanship and material. It cannot be disputed that in some cases the more important engineering undertakings may require far more elaborate details and specifications. These instances, it will be quite impossible to provide for in general specifications such as those proposed, though special clauses can be readily added as occasion demands.

As a commentary on the way the English manufacturers have handled the whole situation, it may be said that individually the blast furnace people have agreed to sell all the pig iron wanted for export on chemical specifications. Officially, when written to, they disclaim any intention of so doing. It is merely the very natural disinclination to tread on new paths and to give away a business advantage they now hold over their customers. The world advances, and in the end the best counsel will prevail. Why not hasten international comity by an early agreement on what is just and fair, and satisfactory to the great majority?

XUM

A New Material for High Grade Castings

By J. E. Johnson Jr., New York

It is my purpose in this paper to try and explain some of the discrepancies between the scientific knowledge of the theoretical metallurgist and the facts of practice and experience as you find them. The explanation I have to offer is opposed to one of the most strongly entrenched opinions of theoretical metallurgy and I do not expect that it will be accepted without question, but if those interested will be generous enough to make a trial for themselves of the correctness of my statements in ways which are capable of absolute demonstration, I believe that they will come to agree with my conclusions, whatever they think of the method by which I reached them.

Let me say by way of introduction that practically all my business life has been spent in the manufacture of pig iron and that during most of it I have been accustomed to have made from the hot metal at the furnace the greater proportion of all those castings used around the plant, and subsequently to have these castings machined in our own shop, so I think I approach the foundryman's side of the many questions which arise with a somewhat more liberal attitude of mind than do those furnacemen who are without foundry experience. The character and requirements of foundry work are varied to a greater extent than those of almost any other business, and this has helped to keep obscure some points of practice. The manufacturer of sash weights is not interested in the strength, machinability or density of grain, and only slightly in the fluidity of his metal; the stove founder is greatly interested in the fluidity and clean-casting quality of the metal but not much in the machinability or strength; the manufacturer of small machine parts considers machinability of vital importance but does not care much for strength; the maker of punch and shear frames must have strength and machinability but cares nothing for chilling power; the car-wheel manufacturer must have all

of these, while the manufacturer of steam and ammonia cylinders, and especially automobile cylinders, must have fluidity, strength, machinability and density of grain.

A great many have believed that charcoal iron imparted strength, closeness of grain and chilling power to a degree which could not be explained by analysis, while others have maintained just as strenuously that charcoal iron gave them nothing that they could not obtain just as well from coke iron at a less cost; and some even go so far as to say that charcoal iron is not as good as coke. I spent three years in the manufacture of charcoal iron and carried on what I believe was the most extensive investigation of the subject ever made, and I think that the results of that investigation go far to explain some of these vigorous differences of opinion. These results may be considered under three heads,—sulphur, carbon and oxygen.

Sulphur

Charcoal iron has suffered at the hands of its friends by the statement that its principal advantage over coke iron was in its low sulphur, and the sulphur contents of charcoal iron have often been given as under 0.01 per cent, when as a matter of fact the best of the Lake Superior charcoal iron probably will not average below 0.018 per cent and the southern and eastern brands, which command a premium of many dollars a ton over Lake Superior, frequently have as much, if not more, than coke iron. As a matter of fact, it is extremely doubtful if the sulphur contained in good charcoal can be carried off by the slag so as to reduce that in the iron much below 0.02 per cent without bringing about conditions which hurt the iron a great deal more than the reduction of sulphur helps it. That sulphur is not the key to the problem should have been obvious from the beginning, for an iron 0.02 per cent in sulphur which can readily be obtained from a coke furnace, remelted with one foundry coke may easily give 0.08 per cent sulphur, while an iron of 0.04 per cent which is higher than the average of sulphur of good coke iron, remelted with another coke may give 0.07 per cent. I do not want to be misunderstood in this matter. I regard sulphur as the foundryman's worst

enemy, and if a recent invention in cupola practice which promises to remelt iron without increase in sulphur, fulfills the expectations based on experimental runs, it will mark the dawn of a better day for foundrymen in more than one respect; but to claim that a reduction of sulphur in the original iron of only a small fraction of that which may be made by an ordinary change in coke, is worth the difference in cost of charcoal and coke iron, is to my mind, ridiculous.

Carbon

The determination in total carbon in iron has been until recently one of the greatest bugbears of the laboratory. I have tried for years to get chemists to give me a periodical carbon determination and have always been met with a loud wail of protest over the time and room required to rig up the apparatus and the amount of other work crowded out by it. Moreover, the determination is one subject to very large errors and some of the very best chemists I have ever known have turned in results which they themselves have subsequently found to be in error to the extent, in some cases, of one per cent or more. The introduction of the direct combustion of drillings in a stream of oxygen in a long silica tube and the determination of the resulting Co_2, for carbon determination in steel, improved matters very greatly and I had the method introduced for the determination of total carbon in cast iron and finally put an extra man in the laboratory to enable us to get a carbon determination on every cast. Many difficulties were found even with this method when applied to cast iron on account of the high carbon and low fusibility, but after months of work we succeeded in getting concordant results which we could check very closely. We were making test bars from every cast and we soon found that the iron could be divided into three qualities, normal iron of standard strength and chill; extra strong iron with high chilling power and coke iron with very low chilling power. After many months of observation and working out many tests we found that high carbon was responsible for the production of the third grade. Charcoal is a very soft and exceedingly cellular fuel and under certain conditions

of operation, which are very complex and with which I will not burden you, the iron takes up much more carbon than it ever does in coke practice; 4 per cent is quite common and sometimes goes as high as 4.75 per cent; while coke iron, as far as I know, seldom goes above 3.80 per cent even when the silicon is low.

Carbon and iron unite in several forms, as you well know; leaving out the question of whether or not there is more than one carbide, we know there is at least one, Fe_3C, known to scientific investigators as cementite. This is white, exceedingly hard and very brittle and is the principal constituent in white iron. This forms solid solutions with pure iron in nearly all proportions, one of which, containing from about 3.90 to 4.20 per cent carbon, is known as the eutectic, which means easiest melting, for the reason that it actually melts at a lower temperature than any other combination of iron and carbon, and this is, therefore, the last to freeze, and when it freezes it forms not a network of interlacing crystals but a series of flat flakes like blocks of mica. These crystals will run in one direction in one of these blocks and in an entirely different direction in the next block, the blocks not being interlaced but joined only at the edges of these flat flakes. This iron breaks by the tearing apart of these flat crystals so that the broken face shows a great number of flat cleavage planes, and was known among expert users of charcoal iron as "High Cleavage" iron long before we discovered the reason for the structure and its effects. When this iron contains from 0.4 per cent to 0.75 per cent silicon it will show a white spot in the center of grey pig, and this white spot is composed of small white flat, almost detached, crystals of the kind I have described. It is then known as "Spotted Iron" and is deservedly held in very low esteem by all who have ever used it. When more silicon is present the white center disappears and the quality, accordingly, is very much harder to recognize. In this state the white crystals have broken down into iron and graphite, and it might be thought that the bad characteristics would disappear, but such is not the case, for the direction of the flakes of graphite is controlled by the shape of the flake crystals from which they are formed.

and these layers of graphite flakes form cleavage planes less marked than those of the white crystals, because they are gray like the rest of the iron, but just as detrimental to its strength.

Characteristics Preserved on Remelting

I may say here, to save any misunderstanding on the subject, that these characteristics are preserved on remelting and imparted to any mixture in which this iron may be used about in proportion to the percentage of it added. This has been demonstrated conclusively by results. An excess of carbon seems to cause the carbon to fall out of solution to the condition of graphite to a greater extent proportionately than occurs when less carbon is present. Probably the large portion of graphite thrown out early facilitates the precipitation of carbon which would otherwise stay combined, and this reduction of combined carbon of course means a reduction of chill. The closer the carbon approaches to the eutectic, say 4.10 per cent, the greater the percentage of the whole which freezes first as eutectic, and if the carbon exceeds the eutectic ratio the excess is first thrown out as graphite and assists in the subsequent breaking down of the iron carbide into iron and graphite, and this action takes place in spite of such a small quantity of silicon as could give chilling power in coke iron, and very great chilling power in good charcoal iron. This action is materially modified by the presence of oxygen, but this phase of the subject can better be discussed after we have considered that.

Here, then, we find the explanation for the extreme statement that charcoal iron is poorer than coke iron. This statement is now seen to be correct in regard to this class of charcoal iron. The carbon content of coke iron seldom approaches the eutectic ratio, and therefore coke iron is free from those serious defects which inhere in the presence of high carbon, to which charcoal is liable. At the same time it is only fair to state emphatically that only a small proportion of the charcoal iron made is of this character. The great proportion of charcoal iron is free from this defect, and for other reasons is materially better than coke iron, and only failure to appreciate the poor quality of this iron and to prevent its shipment to

customers to whom quality is important, is responsible for the harm that this small proportion of the whole has done to the reputation of charcoal iron.

The Effect of Oxygen

I come now to the portion of my subject where I fear that many of you will not agree with me, but I ask you to remember that I shall make no statement which has not been tested and proved by all the methods available. We have already seen that an excess of carbon accounts for the iron poorer than the normal, but we have also iron of quality far higher than the normal in which the carbon is about the same as in normal iron and also about the same as in coke iron but it is much stronger than either, even if of identical composition in all the ordinary elements. We proved by many experiments that this superiority was preserved on remelting and that irons of great strength and chilling power originally had as great, if not greater, strength, on remelting in a covered crucible to prevent the entrance of air, sulphur from fuel, etc., and that the same was true when remelted in the cupola. This proved that there must be some element in the iron which produced these results, and after many years of holding the opposite belief, I came to the conclusion that the presence of a certain amount of oxygen produced these beneficial effects, in spite of the universal prevalence of two opposing views; first, that oxygen could not remain in iron on account of the reducing action of the carbon, silicon and manganese; second, that it could be present, but exerted a very injurious effect.

In the course of an investigation extending over two years and carried on by means of physical tests, remelts, photomicrographs, and direct determinations of oxygen, we found that all the abnormally good iron contained oxygen to the extent of 0.04 to 0.10 per cent; that the normal charcoal irons contained 0.015 to 0.025 per cent, and that the poor iron, in addition to high carbon, contained under 0.01 per cent oxygen, and coke irons contained 0.01 per cent or less. We went further, and put oxygen into normal and poor irons by remelting them with a highly oxidized product made only when the furnace had been

in trouble and was working too cold to make merchantable iron. By this means we made iron as strong as the best the furnace ever produced. We also tried weakening these irons with deoxidizers, such as titanium and aluminum, and while we could not get out very much of the oxygen, we reduced it enough to reduce the strength. We can, therefore, say that—

1. We have found oxygen present in strong irons, and found it almost wholly absent from weak ones;

2. That we have strengthened very weak irons by putting oxygen into them and made them equal to the best;

3. That to the extent we have succeeded in removing the oxygen we have made weaker.

How the Oxygen Acts

The effect of the oxygen seems to be twofold. First, it closes up the grain of the iron by reducing the graphite from flat flakes to small round balls; second, it changes the form of crystallization of the iron, and seems to prevent, to a very large extent, the tendency of the eutectic to form in the flat crystals I have described above, and causes it to form a meshlike crystalline structure, which I am sure you will say, from looking at a photomicrograph of it, is necessarily much stronger than the structure of flat crystals. The effect of both these two changes is in the same direction as regards strength. The latter makes the matrix or groundwork structure stronger; the former reduces the number and size of the gashes in that structure made by the graphite.

Leaving for another time and place the explanation of the cause of these results and our many unsuccessful attempts to produce strong iron by different methods of operating the furnace, we may pass at once to the fact that I finally succeeded in developing a method of introducing oxygen into iron after it left the furnace; not in variable, one might say, accidental amounts, as in the case with the best operated charcoal furnaces, but under conditions which prevent the absolute control of the process as to both temperature and chemical composition; so that we can virtually saturate the iron with oxygen for the given conditions. This process is carried out, in part, in the

Bessemer converter. The silicon is blown out of one portion of the iron so that the oxygen may be made to enter it, which is impossible if more than a small quantity of silicon be present. Owing to the nature of the reactions in the Bessemer converter, we can remove the silicon virtually without affecting the carbon, or we can, if we desire, reduce the carbon to any desired point. To this blown metal we add pig iron straight from the furnace and thereby restore the silicon of the whole to any desired amount. This does not remove the oxygen if the process is properly controlled. Knowing the composition of the two portions of the mixture and the temperature conditions, you will see that we can make up an iron of the desired composition, just as a druggist fills a prescription, and obtain both the analyses and the properties desired.

Now, as to the properties of the resulting metal. This iron is not intended as a scrap carrier in the ordinary sense of facilitating the use of the largest possible proportions of the poorest and worst mixed scrap. That requires a softener such as silicon or a certain amount of manganese. Oxygen gives a strength and chilling power, exactly opposite properties to those conferred by silicon, and by manganese in moderation; therefore, it would be, to the highest degree, foolish to add it when the properties they give are required.

The fineness of the grain of the iron is remarkable, as you will see by samples, which contain 1.26 per cent silicon.

One of the notable characteristics of this metal is its sensitiveness to chilling influences. It will be noted that the samples have not the faintest sign of a chill as cast, but this iron took a chill of about 1/4 inch when cast against an iron chilling surface. A coke iron of this sulphur could not be made to show any chill above 0.85 per cent silicon, and would not show as much as this iron when cast against a chill plate until it was down to 0.65 or 0.75 per cent silicon, and then even when cast in sand it would show some chill. As compared with coke iron, therefore, this iron has the advantage that, though quite a wide range of silicon, if cast against a chill, it will chill white and very hard; whereas, if cast in sand it will be gray. This wide range of silicon within which we can obtain the chill desired, is

a great advantage, as a slight change of silicon will not throw the product from too much to too little chill. The character of the chill is very different from that of coke iron; instead of being highly crystalline made up of flat highly polished surfaces at right angles to the chilling surface, it is almost non-crystalline and breaks into smooth, rounded surfaces, instead of flat surfaces at sharp angles with one another. The result is to make a very much tougher and more endurable chill, and when used for car wheels, reduces to a minimum the danger of shell-outs.

Tests of Standard and Oxygenized Charcoal Iron

Kind of Iron.	Combined Carbon.	Graphitic Carbon.	Total Carbon.	Manganese.	Phosphorus.	Sulphur.	Silicon.	Transverse test. Actual breakage load.	Tensile strength. Lbs. per sq. in.	Brinnel hardness.
Eastern....	72	2.18	2.90	.45	.141	.120	2.95	4,575	34,100	217
Eastern....	72	2.18	2.90	.45	.141	.120	2.95	5,025	35,300	212
Eastern....	72	2.18	2.90	.45	.141	.120	2.95	4,425	35,200	...
Eastern....	72	2.18	2.90	.45	.141	.120	2.95	4,030	36,900	...
J. E. J.....	83	2.60	3.43	.26	.35	.036	1.07	4,505	34,800	202
J. E. J.....	83	2.60	3.43	.26	.35	.036	1.07	4,825	33,800	207
J. E. J.....	83	2.60	3.43	.26	.35	.036	1.07	4,825	34,100	202
J. E. J.....	83	2.60	3.43	.26	.35	.036	1.07	4,815	33,800	196

Note:—Transverse tests made from 1¼ inch round bar, 12 inch centers, as per specifications of American Society for Testing Materials.

This difference in crystallization appears to be fundamental, since the presence of oxygen seems to overcome entirely the tendency to form the flat, smooth crystal eutectic, which I have described above, and forces the iron to crystallize in a meshwork of interlocking crystals even when the carbon is high. This action is of great importance, because carbide of iron which contains 6.67 per cent carbon, is the hardest compound of iron carbon known and is the component of the structure which gives to chilled surfaces their wear-resisting properties, and the more there is of it present, the harder the surface. Under furnace conditions it is generally the case that the higher the carbon the lower the oxygen and the more certain the iron is to have the flat, worthless eutectic structure, and to throw

most of its carbon into the graphitic condition, destroying the chill. But, by the new process, a high carbon iron can be treated so as to saturate it with oxygen, with almost no reduction of the carbon, and thus secure maximum chill and maximum strength.

It is my opinion that the great value of the cold blast charcoal irons for chilling purposes comes from the fact that the great quantity of fuel present on the hearth in their manufacture tends to make them high in carbon, while the low temperature there enables them to be high in oxygen also;

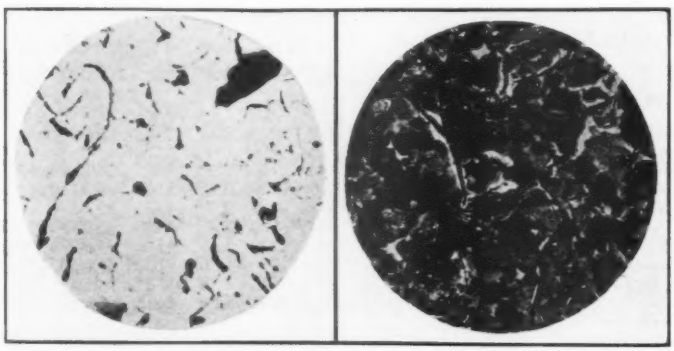

FIG. 1—COKE IRON UNTREATED, UNETCHED
Magnified 100 diameters

FIG. 2—COKE IRON UNTREATED, ETCHED
Magnified 100 diameters

conditions which cannot be realized with any other method of furnace operation. This has permitted the survival of cold blast charcoal iron until now, in spite of its enormous cost.

The strength of this iron is great, as compared with any coke iron and most charcoal irons, being only equalled by some of the most expensive Eastern charcoal irons. Harry B. Swan, of your committee, has made some test bars from crucible remelts of this iron, and through his kindness I am able to give herewith the results of these tests, as well as the analysis of the iron. You will see from these tests that we have been able to make, at slight expense, from coke iron, a product which is the equal in strength of the Eastern charcoal irons.

which are noted for their high quality and high price. I have information from one of the large wheel manufacturers of the country that they had found the chilling power also of this iron to be the same as that of one of the famous Eastern charcoal irons. I am advised by Mr. Swan that he also cast some of this iron into cylinders and had found the grain fine and good and that it machined well, although somewhat hard. I would suggest that an iron of this strength will never machine as easily as a weak iron and that whatever difficulty there may be in machining it is attributable to its strength rather than

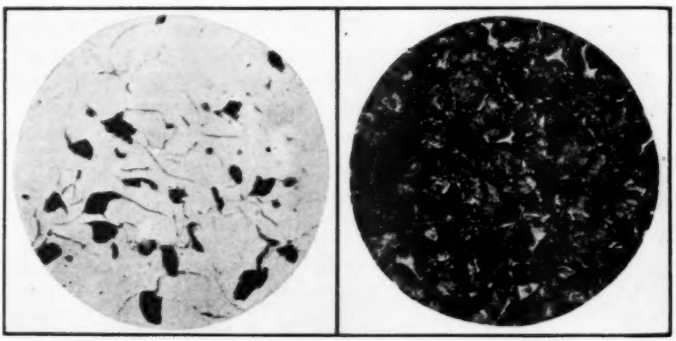

FIG. 3 — COKE IRON TREATED, UNETCHED
Magnified 100 diameters

FIG. 4 — COKE IRON TREATED, ETCHED
Magnified 100 diameters

to hardness, in the ordinary sense of that term; or, to put it in another way, if cylinders are to have the strength and wearing qualities which are their first requirements, then a certain kind of hardness is indispensable.

There are some purposes for which carbon is desired to be low; it is commonly considered that a reduction of the carbon is the principal function of the air furnace. We may say, almost with certainty, that this is not altogether true, and that the introduction of oxygen is the principal purpose accomplished by it, although the opposite is commonly supposed to be the case. In any event, by the new process, we can supply iron with the carbon reduced to any desired point, with any

silicon required, and with more oxygen than can possibly be introduced under air furnace conditions; by the use of this material we believe that you will be able to supply castings better than "Gun iron" without the use of the air furnace, and that we can supply a metal for malleable castings which can be melted in the cupola and cast direct. These things have not yet been done, but these developments join on so naturally with what we have already proven and accomplished, that I hope we shall not be considered overconfident in saying that we hope to accomplish these also.

You will see, I think, that whatever you may think of the methods of reasoning by which the results were attained, that there is a new material at your service when you wish to produce castings possessing great strength, deep, tough chill, close grain, machinability, and wearing quality.

One of the best features of the situation is that we know what the properties of the iron come from and can control and regulate them virtually at will, a thing never possible before.

In conclusion, I wish to thank you for your patience in hearing me out and to express my conviction that with the aid of this material you will achieve for the American foundry trade still greater glories than those you have won for it in the past.

Discussion of A New Material for High Grade Castings

THE CHAIRMAN, MR. ALFRED E. HOWELL:—Mr. Johnson, will you tell us how you introduced the oxygen?

MR. J. E. JOHNSON JR:—We take the iron and put it in a Bessemer converter and blow it just as cold as we dare and get it out of the converter. We blow it only until the silicon is gone; the carbon is practically undisturbed; then we mix it with an equal volume of iron containing twice as much silicon as we want in the final mixture, so that the average is what we want, and that is really all there is to the process. There is a thorough mixture and the oxygen introduced at the low temperature will stay in.

MR. P. H. ROOT:—Mr. Johnson, you made a statement that this iron could be melted in cupola practice without changing its structure.

MR. T. E. JOHNSON JR:—That is correct.

MR. P. H. ROOT:—And that in air furnace practice, the temperature is so high as to reduce it to the grade of pig iron from which it was made.

MR. J. E. JOHNSON JR:—No sir, I didn't mean to give that impression. The point is that in the air furnace, you can get the temperature very high, and I have heard a great deal from air furnace men about burning the iron; in an air furnace, if you get it too hot, you spoil the iron by burning the oxygen out, because the reaction will take place at a low temperature, but not at a high one. When you overheat the iron in air furnace practice and get a bad result, the reason is that you burn out some of the oxygen. This iron is particularly adapted to the purposes of the chilled roll people and they are taking it up.

A New Design of Foundry Cupola

By G. R. Brandon, Harvey, Ill.

This paper will describe a new cupola designed with the special object of meeting the severest service requirements for large capacity and heats of long duration such as obtain in pipe and wheel foundry practice, and also in implement and machinery foundries of the largest output.

The development of this design has been gradual, the first cupola of this type of construction having been installed in 1908. To increase ease of handling and simplify the construction certain details have been incorporated. This design aims to avoid one of the greatest limitations for hard service in the ordinary construction, which is the location of the tuyeres all within the windbox. An individual blast box is used for each tuyere, similar to that used in Bessemer cupolas. This simplifies cupola operation greatly. The ordinary construction of wind box which extends to bottom plate also is done away with and a wind belt substituted.

Simple attachment of tap and slag spouts to the shell is also desirable in heavy duty cupolas and a design for the base which would be of ample strength and at the same time of simple and reliable construction was considered advisable.

The construction may be described as follows: The base consists of a heavy steel plate, square on the outside dimensions and with a circular opening in the middle slightly larger than the inside diameter of the lining. This plate is securely riveted to and supported by two steel H-beams at the front and rear. These beams are supported at the ends with cast iron cylindrical columns furnished with an ample base flange to rest on concrete foundation. The top flanges of the columns are machined so as to accurately fit the flanges of the steel beam, and are bolted thereto by bolts of large diameter.

An angle bar is riveted to unsupported edges of the bottom plate to give additional stiffness. A heavy angle makes the connection between the bottom plate and shell, and is

securely riveted to both. This construction gives great strength as the circular shell is of such a form as to give maximum strength against buckling from vertical loads or internal pressure and is comparable to a girder of the height of the stack to withstand vertical loads.

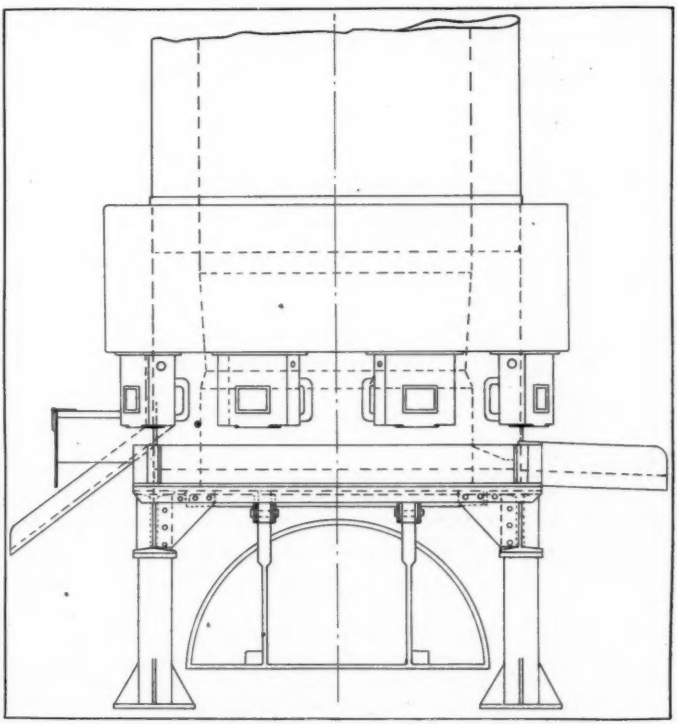

FIG. 1—ELEVATION OF HEAVY DUTY CUPOLA

The windbox is of belt form with all joints calked air-tight. The blast entrance is the tangential type which introduces the air into the windbox with minimum friction.

Construction of the Blast Boxes

The blast boxes are cast iron with flanges for attachment to the shell and the underside of the windbox. These joints

are fitted with gaskets and are air-tight. Each blast box is provided with a peephole and cover opposite the tuyere. Also, a frame with a fusible or combustible insert is attached to the underside of each tuyere to serve as a safety device in case slag or metal overflows the tuyere. Each blast box is also furnished with a damper for regulating the amount of air

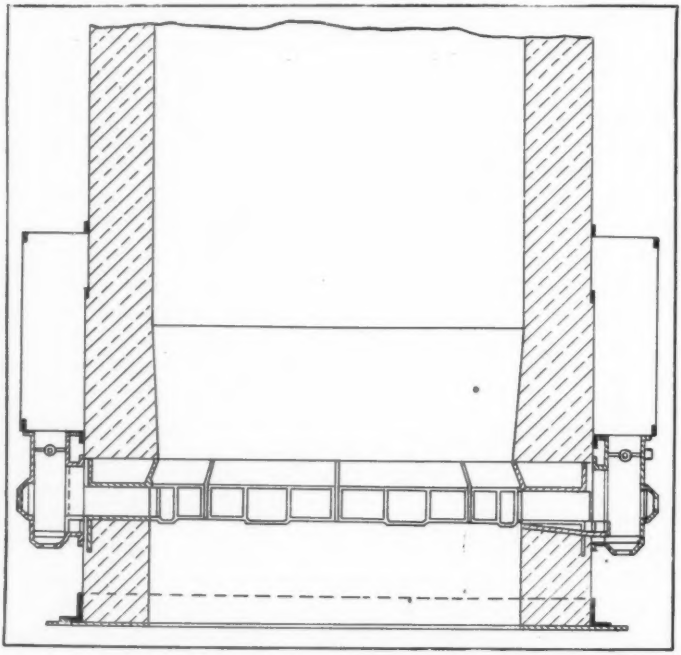

FIG. 2—SECTIONAL ELEVATION THROUGH OPPOSITE BLAST BOXES

passing from the windbox to the tuyere. The tuyeres are in one row and form a continuous inlet from the shell to the inside of the lining. The tuyere castings are made in segments with a removable top all bolted together through flanges and are of rigid construction.

The top has a flange at the inner edge, extending upward and inwardly and the lining is projected to come flush with

inside of flange. The diameter of the lining at this point is two to three inches smaller than at the melting zone, to which point the lining is gradually sloped.

The stack for this cupola is of heavy construction, and all the joints are riveted. Supports are furnished at proper intervals for the lining and an angle is placed around the top.

Two charging doors are provided and when desired these doors are of the lifting type, operating in vertical guides, counterweighted and fitted with an apron attached to the

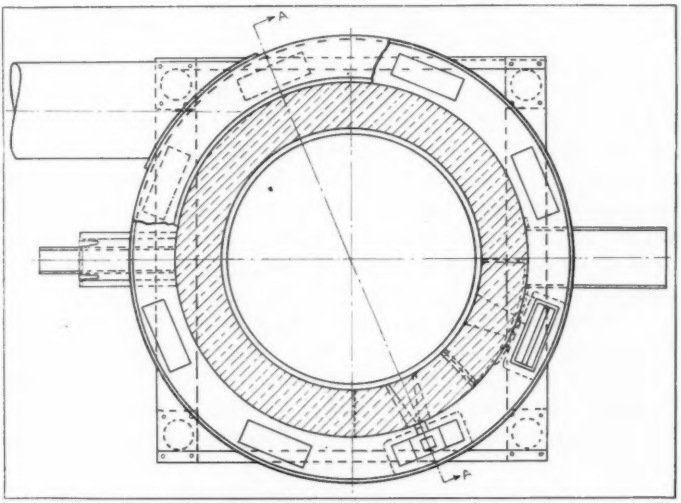

FIG. 3—HORIZONTAL SECTION

shell to serve in connection with a charging machine. Special doors may be installed for any method of power charging.

The lining recommended consists of blocks 6 x 9 inches wide and 6 inches thick, forming an inner lining, backed by regular square and arch firebrick set edgewise against the shell.

The tuyeres are of such form that it is not necessary for the bricks to fit around invidual tuyeres and the lining is easily laid at this usually difficult point. This saves at least a day's time in relining.

Among the principal advantages of this new construction is the arrangement of the damper in each blast box, which enables the attendant to readily control lighting up and burning through the bed, which must be burnt through evenly before last of the coke is put on and charging is commenced to obtain the best results. Or, in case the cupola is melting badly and great oxidation is taking place at one point, which can be noted at the charging door, the individual blast gate gives the operator a means of overcoming the improper working condition. Also, by proper regulation of the dampers, unequal cutting of the lining is prevented.

Another superiority is due to the arrangement of continuous annular tuyeres in combination with liberal size peepholes which permit inspection of practically the whole interior of the cupola and of reaching every part with a poke bar if necessary. The inwardly extending flange on the tuyere cover causes the molten metal and stock to descend clear of the tuyere opening and insures full admission of the blast. The area of the tuyere opening at the inside of the lining is very liberal.

The design of the base with the square bottom plate and columns located at the corners gives clearance for the bottom doors and for the cupola tender in cleaning out the drop and daubing up. With a steel base plate there is less danger of cracking as in the cast iron construction when water is thrown carelessly on the cupola after dropping the bottom.

The simplicity of design also permits the figuring of all stresses with the greatest facility and the use of ordinary commercial sections insures better workmanship in the shop.

The bottom doors have perforated cast plates with deep ribs and heavy hinge lugs, designed specially to equalize shrinkage and withstand heating and cooling. The doors are provided with pads for props and are arranged for the attachment of bottom door hoists. The lugs for the bottom door pins are structural steel and are bolted to the steel bottom plate.

An important feature in large cupolas is the provision for an operator's and tapper's platform of convenient height

and substantial construction. This design of base readily lends itself to this construction. While I admit some features of this design are old, it is claimed that the combination is new and affords facilities seldom brought together for convenience, safety and efficiency in cupola operation.

Discussion

MR. W. R. BOSSINGER:—I would like to ask what improvements you would claim over the old style cupola on this design?

MR. G. R. BRANDON:—The improvement is simply a question of maintenance and of practical management. The wind belt can easily be kept tight and there would be no danger of rusting out. The blast boxes are easily gotten at, and also one point I didn't mention, the blast box is fitted with a slide or gate to shut off the air; that allows regulation of combustion inside the cupola, also cuts off a wind-box in case you want to poke the tuyeres.

MR. W. R. BOSSINGER:—Would your pressure be uniform with all tuyeres open, more so than in the old style?

MR. G. R. BRANDON:—Not more so that the old style; it would be just the same throughout the wind box and blast box as independent regulation is the object desired; if there is too much oxidation opposite one tuyere, you can cut off the blast.

MR. S. D. SLEETH:—Is your tuyere continuous or do you have a space between each tuyere? I notice you have eight openings.

MR. G. R. BRANDON:—There are openings in the shell to admit the blast but the tuyere itself is continuous.

MR. S. D. SLEETH:—Do you find that having the tuyere continuous gives better results than having a space between each tuyere?

MR. G. R. BRANDON:—Not essentially, the type of tuyere I have been used to gives a practically continuous opening, and this is simply a modification. It is more simple than the flaring type because the lining is simpler to put in.

MR. S. D. SLEETH:—We have tried the continuous type. We run sometimes for 20 hours but have not got as good results as with a space between each tuyere. The only reason I can think of for that is that it doesn't form so much slag the whole way around when the air enters and there is a space between each tuyere. When the air goes in a continuous tuyere, you have got slag forming above your tuyeres the whole way around, but if you don't have a continuous tuyere, the air doesn't form so much slag around your tuyere. I don't see much difference between this cupola and the ordinary equipment of the day where you have a bustle and clearance between tuyeres.

MR. G. R. BRANDON:—I think the continuous tuyere will give as good results as the other. In this cupola the tuyeres are at the level of the blast box, under the bustle and therefore don't enter from the wind-box. You can have any clearance you want and any sort of opening together with any sort of tuyere you want inside this opening.

MR. S. D. SLEETH:—But if you enter from the bottom of the wind-box with eight openings, wouldn't you get the same results? I don't see yet where it is much different from the ordinary cupola.

MR. G. R. BRANDON:—Excepting that you have the combination of the wind-box and blast box. It is an old device used in Bessemer practice for many years, but that, in connection with the design of the bottom plate and the H-beams to support the cupola and the straight column will make a new combination.

MR. S. D. SLEETH:—But it don't help to melt iron any faster.

MR. G. R. BRANDON:—It makes a cupola that is simple in construction and very easy to maintain and supervise.

MR. STANLEY G. FLAGG III:—Is there anything new in the lining?

MR. G. R. BRANDON:—No, we do not claim that you gain anything in any of those points, it is simply a more practically operated cupola for heavy service.

Calculating Mixtures for Malleable Cast Iron

By HARROLD HEMENWAY, Moline, Ill.

The manufacture of malleable cast iron at the present time is carried on with a great deal of confidence and assurance, as compared with its manufacture in the earlier years. Its production was formerly accompanied with a great deal of what might be termed contradictory knowledge. This was undoubtedly due in most cases to the close attention given each local condition, having a tendency to hold back that confidence in the art, which so benefically encouraged its former rival, gray iron.

Its adaptability to an almost unlimited variety of work makes it an indispensable article of construction, having superseded the gray iron casting in car building, and greatly taken its place in the construction of agricultural implements. The smoothness of its surface together with the uniformity of structure, makes it particularly adapted for carriage and saddlery hardware castings, being greatly superior to the hand forged article formerly used.

This demand for malleable castings, as compared with former years, increased the production more rapidly than any other branch of the metal world. There is no secret about its production, and the interchange of ideas which is now prevalent has helped its advancement more, having done away with the jealous restrictions of past years. The entrance of the chemist was productive of greater benefits than in the gray iron industry. It was then possible to make a more careful selection of the raw material for the mixture, and with careful analysis the malleable casting made a phenomenal advance in the casting art.

The change in design to the thinner section as compared to the gray iron weight was the greatest barrier to be overcome. It was not until these things were accomplished and complete confidence established that the malleable casting reached the high standard of commercial value it has now attained.

In this paper I will treat briefly of the elements entering into the manufacture of the malleable casting, and explain fully a system of calculating mixtures.

There are five elements which enter into the manufacture of the malleable casting. These are divided into two classes, the positive and negative elements, according to their effect upon the finished casting.

The negative elements are sulphur and phosphorus. Sulphur exerts the most negative influence of any of the metalloids found in the pig iron used for malleable purposes. There are no beneficial results arising from the presence of sulphur and it must of all impurities be most avoided. The lower the percentage is in malleable, the more satisfactory will be the product. Sulphur increases during melting and annealing. Too much sulphur makes the iron hard and brittle and it will not anneal. The charge should not contain sulphur in excess of 0.045 per cent. The amount specified in the pig iron for malleable is 0.05 per cent and under. The lower percentage being the most preferable, as it is necessary to remelt a large percentage of sprue high in sulphur which has been absorbed from previous melting.

Phosphorus in connection with silicon has an influence upon the fluidity of iron. Phosphorus is not a dominating element in pig iron, but depends entirely upon silicon for its assertive qualities. This is best shown in casting gray iron where the percentage of silicon and phosphorus are both high, and the molten metal has great fluidity. In making malleable it is not possible to carry a high percentage of silicon, and as the percentage of phosphorus must also be low it does not quite perform the same function. However its working can be traced in the melting furnace. Too much phosphorus will not allow the carbon to combine. Should there be an excess of phosphorus present in the finished casting it will cause hardness, similar to an excess of sulphur. In fact it is difficult to draw the line between the effects of these two metalloids in this respect after the casting has been annealed. There will be no bad effects if the amount present does not exceed 0.20

per cent with the highest limit of safety placed at 0.225 per cent.

The positive elements are silicon, carbon and manganese.

Of all the metalloids contained in pig iron, silicon is probably the one upon which the greatest dependence is placed. It is conceded that silicon promotes the separation of graphitic carbon, and in the malleable casting these two metalloids assume important parts. Silicon grades the pig iron. It is formed from the silica in the charge, through the blast furnace into pig iron, which when melted in the air furnace as malleable is the synonym for heat units. It should be clearly understood that the term silicon means "heat."

In calculating mixtures for the casting of light work the percentage of silicon is usually kept high, as a metal is desired which will retain its heat for a considerable period, and the resource for it is higher silicon. Without its dominating presence in the mixture, iron will not remain hot and liquid for the successful casting of light work.

Carbon an Important Element

Carbon which has always been considered the most important metalloid contained in pig iron, still is dependent upon some other metalloid for its presence either as graphitic or combined carbon. Silicon has an all powerful influence upon its formation and the two should be rightly considered together.

There are no low carbon pig irons produced, and the total carbon varies but little in No. 1 or No. 6 iron, while the silicon changes radically. The higher the percentage of silicon the higher will be the amount of graphitic carbon present, the lower the silicon the less will be graphitic.

In calculating a mixture, it is not necessary to figure the carbon contents, for when the other elements are within the proper limits, the percentage of silicon should indicate the proportion of combined and graphitic carbons. For this reason it is useless to specify any carbon or form of carbon in the pig iron for malleable, for the carbon point below which it is impossible to anneal, is well defined and never is reached even by the amount of steel scrap it is possible to add satisfactorily to the mixture.

XUM

Manganese is perhaps the most peculiar metalloid found in pig iron. In the malleable furnace it is known that manganese will eliminate portions of the sulphur which will pass off through the slag and might be looked upon in the light of a purifier. Manganese will combine in any amount with iron, and a high percentage affects the total carbon. Manganese materially affects the shrinkage, and when the percentage is low makes a weak dirty iron with increased shrinkage. Higher manganese makes a stronger iron, with less shrinkage, but when the percentage is too high there will be trouble in annealing. In calculating mixtures for malleable cast iron, a great many adverse conditions arise, owing to the fact that no two furnaces work alike. The peculiar local conditions must be studied and understood, to determine the amount of silicon necessary for the mixture.

Silicon Important

If a whole heat were charged of No. 1 iron, high in silicon and graphitic carbon, there would be the greatest difficulty experienced in getting the carbon into combination. Carbon combines at a very low latent heat temperature and in the No. 1 iron the latent heat unit is high, the silicon must be burnt out to a great degree and the carbon will not combine in this instance until the silicon or heat units have become materially reduced in power.

This is the cause for iron remaining gray in the test after it is hot enough to pour, as the excess silicon is producing enough heat to retain the carbon in the graphitic form. As the silicon burns out, the tests will become less mottled until finally a perfectly clear test results.

From this it might be urged that since the malleable founder wants carbon in the combined form, he ought to charge into the furnace pig iron having the carbon in that form. This would not be good practice, because the iron would contain no "life" whatever, its silicon and carbon having already been reduced. It is found necessary to use a proportion of pig iron high in graphitic carbon, in order that the mixture may contain enough heat to take up for the period of melting and bringing same up to the pouring point.

While the presence of silicon is a necessity in the melting furnace, still an excess of silicon is a hindrance in the annealing process. If the carbon and silicon are in the proper proportions the carbon will go freely and the anneal may be shortened. But if the carbon is held back here by a too high percentage of silicon the resulting material will show a steely fracture which would lead a great many to think that the iron had not been properly annealed and is still hard iron. The silicon must be reduced in the original mixture before the carbon will "let go" in the anneal.

It is necessary to choose the irons from those grades, which when melted and brought up to the pouring point will contain enough silicon to impart latent heat to the bath, and at the same time not interfere with the combination of carbon.

From this it will be seen that silicon is the most important element to be considered, both in melting and during the time of annealing. In calculating a mixture it is good practice to use irons varying completely in chemical analysis for the benefit of obtaining good averages.

For the average malleable casting, the silicon in the hard iron should be between 0.60 and 0.75 per cent, 0.65 per cent would be a fair average.

In making a malleable mixture the first factor to be considered is the amount of sprue to be used together with the amounts of malleable and steel scrap. Let us consider the sprue graded as No. 5 iron, having the silicon at 0.60 per cent as a constant. This will work out to the best advantage even though the silicon in some heats will analyze 0.75 per cent and higher. The total percentage of carbon in the sprue is much lower than the total percentage of carbon in the pig iron, and by figuring this at a lower percentage, some allowance is made for this reduction in carbon.

Calculating a Mixture

In calculating malleable mixtures using the sprue graded as a No. 5 iron, it will be easy to make a mixture using the pig iron graded as Nos. 1, 2, 3 and 4 iron having the approximate relative proportion as nearly as possible to the sprue

figured at 0.60 per cent silicon, and used as a No. 5 iron. A mixture can be made as follows:

TABLE I.

	Silicon, Per cent.	Amount, Pounds.	Silicon in Mixture.
No. 1 iron.....	1.52	30 =	45.60
No. 2 iron.....	1.29	40 =	51.60
No. 3 iron.....	1.06	50 =	53.00
Sprue No. 5 iron.....	0.60 40%	80 =	48.00
		200	198.20

198.20 ÷ 200 = 0.991 per cent of silicon the mixture contains.

Grade		3.30
		660
120		640
80		+20
40 No. 2 iron.....	30	No. 1 iron
	50	No. 3 iron
	80	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

In calculating a mixture by the above method the different amounts used, are always figured in even hundred pounds. For this reason it is not necessary to consider the two ciphers in figuring a mixture, and the two ciphers have not been taken into consideration in determining the silicon contents of this heat. The mixture shown is for a ten ton heat and will be figured at 200 instead of 20,000 pounds.

The grade at which the heat is to be figured must be determined first, and in this case I have selected 3.30. Multiplying the grade 3.30 by the size of the heat in pounds, 200 equals 660, the base number from which to calculate the mixture, and the different amounts of pig iron and sprue used when multiplied by their grade numbers and added will equal this base number.

Taking the percentage of sprue required and subtracting this amount in pounds from the size of the heat in pounds, the remainder indicates the amount of pig iron to be used.

If all the pig iron used was to be graded as No. 2 iron and using the sprue as No. 5 iron, a base number for a ten ton heat using 40 per cent sprue would be determined as follows:

TABLE II.

10 ton heat	200	
40 per cent sprue No. 5 iron	—80 × 5	= 400
Pig iron graded as No. 2 iron	120 × 2	= 240
	200	= 640

In calculating a ten-ton heat having a grade of 3.30 the base number is 660, and the base number using 40 per cent sprue is 640. Subtracting 640 from 660 leaves a remainder of +20. For this reason it is necessary to use 2,000 pounds more of the No. 3 iron than the No. 1 iron to obtain a grade of 3.30, making the amounts of iron used when multiplied by their grade numbers and added, equal 660. Using 3,000 pounds of the No. 1 iron added to +20 equals 5,000 pounds of the No. 3 iron, and these added and the result substracted from 12,000 pounds equals 4,000 pounds the No. 2 iron required. The calculation is proved as follows:

TABLE III.

No. 1 iron	30 × 1	= 30
No. 2 iron	40 × 2	= 80
No. 3 iron	50 × 3	= 150
Sprue No. 5 iron	80 × 5	= 400
	200	= 660

the base number from which the calculation is made.

Since the amounts of the different irons used when multiplied by their grade numbers and added equal 660, the grade is 3.30.

The amounts of malleable and steel scrap used, which are listed at the lower left hand corner in Table I, are deducted from the amount of sprue used, and the grade of the heat is raised or lowered as the amounts are decreased or increased.

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Thus by adding 100 pounds of steel scrap, it is necessary to reduce the grade five points, and when leaving out 100 pounds, it is necessary to increase the grade five points. Malleable scrap does not have the same effect as steel scrap, and it is not necessary to change the grade unless the amounts used are increased or decreased at least 200 to 300 pounds or more.

From this mixture it will be seen that by using the sprue graded as No. 5 iron and the pig iron graded as No. 2 iron, it is possible to obtain a base number and make up a mixture containing all No. 2 pig iron and sprue. However this is not always practical, as it does not always give the desired silicon contents, and it is necessary to use other grades of pig iron, which are indicated as Nos. 1 and 3. The different amounts of iron and sprue used when multiplied by their grade numbers and added, give a base number from which to calculate the mixture. By dividing this base number by the size of the heat gives a number which is termed the grade. In the mixture shown the different amounts of pig iron and sprue used multiplied by their grade numbers and added equal 660. Dividing 660 by 200, the size of the heat, equals 3.30 the grade.

I then determined that by changing the grade 0.05 points would give enough change in the silicon contents to warrant changing the mixture to obtain different results in the furnaces.

A Heat Card

Since enough changes and different mixtures can be made by varying the grade 0.05 points, I selected the grade numbers and arranged a heat card as follows, Tables IV and V.

TABLE IV.

	3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45
200.....	600	610	620	630	640	650	660	670	680	690
205.....	615	625	636	646	656	666	677	687	697	707
210.....	630	641	651	662	672	683	693	704	714	725
215.....	645	656	667	677	688	699	710	720	731	742
220.....	660	671	682	693	704	715	726	737	748	759

TABLE V.

	34 per cent.	36 per cent.	38 per cent.	40 per cent.	42 per cent.	44 per cent.	46 per cent.
	604	616	628	640	652	664	676
200.....	68-132	72-128	76-124	80-120	84-116	88-112	92-108
	620	632	644	656	668	680	692
205.....	70-135	74-141	78-127	82-123	86-119	90-115	94-111
	633	648	660	672	684	696	711
210.....	71-139	76-134	80-130	84-126	88-122	92-118	97-113
	649	661	676	688	700	715	727
215.....	73-142	77-138	82-133	86-129	90-125	95-120	99-116
	665	677	692	704	716	731	743
220.....	75-145	79-141	84-136	88-132	92-128	97-123	101-119

The numbers on the left of the tables indicate the size of the heats in pounds, each increasing 500 pounds; as for example 200 = 10 tons, 205 = 10¼ tons. The numbers on the top of Table IV are the grade numbers, and below these are the base numbers for the different size heats, for the dffierent grades indicated. As for example multiplying 200 × 3.00 = 600, the base number for a ten ton heat figured at a grade of 3.00.

Any other numbers could be selected for the grades and advanced enough points to make a decided change in the mixture. In changing a heat in daily practice, it is not always possible to make the change at an exact grade without changing two or three grades of pig iron, while by changing one grade of iron and the sprue will accomplish the desired results. This for example may make the grade 3.28 or 3.32. The heat card which I use in daily practice has the base numbers figured for different size heats, commencing with a grade of 2.60 and advancing 0.05 points to 4.00.

Table V shows the percentages of sprue and the proportions of sprue and pig iron required for different size heats, together with the second base numbers. As for example 68 is 34 per cent of 200 (a ten ton heat), 132 is the pig iron required to make up a ten ton heat, using 34 per cent sprue. The base number is 604. This is obtained by multiplying the

amounts of pig iron and sprue used by their grade numbers as follows:

TABLE VI.

10 ton heat	200		
34 per cent sprue No. 5 iron	—68	× 5 =	340
Pig iron graded as No. 2 iron	132	× 2 =	264
	200	=	604

the base number for a ten ton heat using 34 per cent sprue figured as No. 5 iron, and the pig iron figured as No. 2 iron.

The heat card which I use in daily practice has the base numbers for the different percentages of sprue and pig iron required for different size heats commencing with 0.30 per cent and advancing 0.02 per cent to 0.60 per cent.

To make up the same size heat having the same grade, but using 46 per cent sprue, referring to the heat card the base number for a ten ton heat having a grade of 3.30 is 660. The base number using 46 per cent sprue is 676. The sprue required is 9,200 pounds and 10,800 pounds of pig iron is needed. The calculation is made as follows:

TABLE VII.

	Silicon, Per cent.	Amount, Pounds.	Silicon in Mixture
No. 1 iron	1.52	42 =	63.84
No. 2 iron	1.29	40 =	51.60
No. 3 iron	1.06	26 =	27.56
Sprue No. 5 iron	0.60 46%	92 =	55.20
		200	198.20

198.20 ÷ 200 = 0.991 per cent of silicon the mixture contains.

Grade	3.30	
	660	
108	676	
68	—16	
40 No. 2 iron	26	No. 3 iron
	42	No. 1 iron
	68	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

In calculating a ten ton heat having a grade of 3.30 the base number is 660, and the base number using 46 per cent sprue is 676. Subtracting 676 from 660 leaves a remainder of --16. For this reason it is necessary to use 1,600 pounds more of the No. 1 iron than the No. 3 iron to obtain a grade of 3.30, making the amounts of iron used when multiplied by their grade numbers and added, equal 660. Using 2,600 pounds of the No. 3 iron added to —16 equals 4,200 pounds of the No. 1 iron, and these added and the result subtracted from 10,800 pounds equals 4,000 pounds, the No. 2 iron required. The calculation is proved as follows:

TABLE VIII.

No. 1 iron	42 × 1 =	42
No. 2 iron	40 × 2 =	80
No. 3 iron	26 × 3 =	78
Sprue No. 5 iron	92 × 5 =	460
	200	= 660

the base number from which the calculation is made.

The silicon contents of these two heats are the same, even though the percentage of sprue used has been changed. This is due to the fact that the irons used are in equal proportion to each other and to the sprue figured as No. 5 iron having 0.60 per cent silicon. Selecting the iron having 1.52 per cent silicon for the No. 1 iron the other grades are determined as follows:

TABLE IX.

	Silicon, per cent.	
No. 1 iron	1.52	
Sprue No. 5 iron	—0.60	
	0.92	÷ 4 = 0.23
Sprue No. 5 iron	0.60	
	+0.23	
No. 4 iron	0.83	
	+0.23	
No. 3 iron	1.06	
	+0.23	
No. 2 iron	1.29	
	+0.23	
No. 1 iron	1.52	

Subtracting the sprue No. 5 iron 0.60 per cent silicon, from the No. 1 iron 1.52 per cent silicon leaves a remainder of 0.92, divided by 4 equals 0.23, the number of points each grade must be increased to be in exact proportion to each other and to the sprue figured as No. 5 iron having 0.60 per cent silicon.

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Referring to the mixtures shown, I will prove how easy it is to change the silicon contents, and the size of the heat by this method. Reducing the grade to 3.20, referring to the heat card, the base number for a ten ton heat having this grade is 640. Subtracting 640 from 660 (the base number used in calculating the mixture) leaves a remainder of —20. Wanting to run the same size heat, it is necessary to change the amounts of pig iron and sprue used to equal —20 points. The change is written as indicated in Table X.

TABLE X.

	Silicon, per cent.	Amount, pounds.	
No. 1 iron.....	1.52	42 + 5 = 47	
No. 2 iron.....	1.29	40	40
No. 3 iron.....	1.06	26	26
Sprue No. 5 iron.....	0.60 46% 43%	92 — 5 = 87	
		200	200 =

1.014 per cent of silicon the mixture contains.

Grade		3.30	3.20
		660	660
108		676	640
68		—16	—20
40	No. 2 iron	26	No. 3 iron
		42	No. 1 iron
		68	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

The change is made as follows:

TABLE XI.

Take out sprue No. 5 iron.....	—5 × 5 =	—25
Adding No. 1 iron.....	+5 × 1 =	+ 5
	0 =	—20

By taking out 500 pounds of sprue No. 5 iron silicon 0.60 per cent, and bring in 500 pounds of No. 1 iron, silicon 1.52 per cent the size of the heat has not been changed, but the

grade has been reduced ten points, which has increased the silicon contents to 1.014 per cent.

To decrease the silicon contents it is necessary to raise the grade. Increasing the grade to 3.35 referring to the heat card, the base number for a ten ton heat having this grade is 670, subtracting 660 (the base number used in calculating the heat) from 670 gives a remainder of +10. Wanting to run the same size heat it is necessary to change the amounts of pig iron and sprue used to equal +10 points. The change is written as indicated in Table XII.

TABLE XII.

	Silicon, per cent.			Amount, pounds.	
No. 1 iron.....	1.52			30 — 3 =	27
No. 2 iron.....	1.29			40	40
No. 3 iron.....	1.06			50	50
Sprue No. 5 iron.....	0.60	40%	41%	80 + 3 =	83
				200	200 =

0.977 per cent of silicon the mixture contains.

Grade		3.30	3.35
		660	670
120		640	660
80		+20	+10
40	No. 2 iron	30	No. 1 iron
		50	No. 3 iron
		80	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

The change is made as follows:

TABLE XIII.

Adding sprue No. 5 iron.....	+3 × 5 =	+15
Taking out No. 1 iron.....	−3 × 1 =	− 3
	0 =	+12

By adding 300 pounds of sprue, No. 5 iron, silicon 0.60 per cent and taking out 300 pounds of the No. 1 iron silicon 1 52 per cent the size of the heat has not been changed, but

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the grade has been increased 0.06 points, instead of 0.05 points, which has reduced the silicon contents to 0.977 per cent.

It is possible to make this change so as to have the mixture calculated at the exact grade of 3.35. To do this it would be necessary to take out two grades of pig iron. The easiest way to make this change is to take out one grade of pig iron, and as there is only 0.23 per cent difference between the different grades the change in the silicon contents would be very slight. The grade is 3.36 instead of 3.35.

To increase the heat to 10¼ tons and have the same silicon contents, referring to the heat card, the base numbers for a 10¼-ton heat having a grade of 3.30 is 677. Subtracting 660 (the base number used in calculating the heat) from 677 gives a remainder of +17. For this reason 500 pounds must be added to equal +17 points. The change is written as indicated in Table XIV.

TABLE XIV.

	Silicon, per cent.	Amount, pounds.	
No. 1 iron.....	1.52	30 + 2 =	32
No. 2 iron.....	1.29	40	40
No. 3 iron.....	1.06	50	50
Sprue No. 5 iron.....	0.60 40% 41%	80 + 3 =	83
		200	205 =

0.991 per cent of silicon the mixture contains.

Grade		3.30	3.30
		660	677
120		640	660
80		+20	+17
40	No. 2 iron	30	No. 1 iron
		50	No. 3 iron
		80	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

The change is made as follows:

TABLE XV.

Adding No. 1 iron.....	+2 × 1 =	+2
Adding sprue No. 5 iron.....	+3 × 5 =	+15
	+5 =	+17

By adding 200 pounds of the No. 1 iron, silicon 1.52 per cent, and 300 pounds of sprue, No. 5 iron, silicon 0.60 per cent, the heat has been increased to 10¼ tons and the irons added are in such proportion that the grade and the silicon contents have not been changed.

To increase the heat to 10½ tons and reduce the silicon contents, referring to the heat card the base number for a 10½ ton heat having a grade of 3.35 is 704, subtracting 660, the base number used in calculating the mixture from 704, gives a remainder of +44. For this reason 1,000 pounds must be added to equal +44 points. The change is written as indicated in Table XVI.

TABLE XVI.

	Silicon, per cent.			Amount, pounds.	
No. 1 iron.....	1.52			30	30
No. 2 iron.....	1.29			40 + 2 =	42
No. 3 iron.....	1.06			50	50
Sprue No. 5 iron.....	0.60	40%	42%	80 + 8 =	88
				200	210

0.978 per cent of silicon the mixture contains

Grade		3.30	3.35
120		660	704
80		640	660
40	No. 2 iron	+20	+44
		30	No. 1 iron
		50	No. 3 iron
		80	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

The change is made as follows:

TABLE XVII.

Adding No. 2 iron.....	+2 × 2 =	+ 4
Adding sprue No. 5 iron.....	+8 × 5 =	+40
	+10 =	+44

By adding 200 pounds of the No. 2 iron silicon 1.29 per cent, and 800 pounds of sprue No. 5 iron, silicon 0.60 per cent, the size of the heat has been increased to 10½ tons and the

grade has been increased 0.05 points, which has reduced the silicon contents to 0.978 per cent.

How Silicon Can be Increased

Let us suppose that it is necessary to change this mixture so as to make a line of lighter castings, for which reason the silicon contents in the mixture must be increased.

In order to use the surplus of sprue to advantage it is necessary to use a much softer grade of pig iron for the No. 1 iron, so as not to reduce the amount of sprue used, but rather be in position to increase this. Upon looking over the stock of pig iron we find a car having silicon 1.88 per cent. The sprue will be figured as having 0.60 per cent silicon and any difference (caused by the sprue having more than 0.60 per cent silicon) will be overcome by changing the grade of the heats. The different grades of pig iron are determined as follows:

Subtracting the sprue No. 5 iron 0.60 per cent silicon from the No. 1 iron 1.88 per cent, silicon leaves a remainder of 1.28, divided by 4 equals 0.32 the number of points each grade must increase to be in exact proportion to each other, and to the sprue figured as No. 5 iron having 0.60 per cent silicon.

TABLE XVIII.

	Silicon, per cent.	
No. 1 iron	1.88	
Sprue No. 5 iron	—0.60	
	1.28 ÷ 4 = 0.32	
Sprue No. 5 iron	0.60	
	+0.32	
No. 4 iron	0.92	
	+0.32	
No. 3 iron	1.24	
	+0.32	
No. 2 iron	1.56	
	+0.32	
No. 1 iron	1.88	

The No. 1 iron used in the previous mixture can now be used as the No. 2 iron, and the No. 2 iron can be used as the No. 3 iron in this mixture. It is only necessary to use a quantity of the iron having 1.88 per cent silicon which is the only

new iron added to the mixture. Having used the other irons in a former mixture and found that these were running properly, this mixture has been completely changed by the addition of one new iron. The No. 2 and No. 3 irons are not in the exact ratio to the No. 1 iron and the sprue, while the No. 2 iron is 0.04 per cent lower, the No. 3 iron is 0.05 per cent higher. Using these in almost equal quantities will accomplish the same results.

It will be seen from these mixtures that it is only necessary to have four grades of pig iron on hand for every brand purchased. Although it is advisable to have a small tonnage of other grades to be used when needed. The pig iron can be arranged in four piles according to the analysis, and the first iron of each grade is laid on the ground in a long row. When other pig iron is received it is piled on top of this row, and according to the analysis of the iron being unloaded, it is put on the pile having its average silicon, allowing a variation of 10 points below and 15 points above the desired silicon.

When the piles have attained a certain height other piles are started in the same manner, and the mixture is weighed from the completed piles, while the new piles are growing in height. When weighing the charges, the iron is taken from the end of each pile, this insuring a perfect mix, and instead of using iron taken for one car for each grade, the charge is made up of iron taken from a large number of cars.

Taking the irons used in the mixtures already shown, the silicon contents for any size heat will be as follows, figuring the heat at the grade indicated:

TABLE XIX.

Silicon Contents of Heat, per cent.	Grade.
1.152	2.60
1.129	2.70
1.106	2.80
1.083	2.90
1.06	3.00
1.037	3.10
1.014	3.20
0.991	3.30
0.968	3.40
0.945	3.50
0.922	3.60
0.899	3.70
0.876	3.80
0.853	3.90
0.83	4.00

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To prove that this method can be used for any size heat, I will make up a 6, 8 and 10-ton heat, having the same grade and silicon contents, but use a different percentage of sprue for each heat. The silicon contents of these mixtures is to be 1.014 per cent. By referring to the foregoing table we find that these heats must be figured at a grade of 3.20. The calculations are made as follows:

TABLE XX.

	Silicon, Per cent.	Amount, Pounds.	Silicon in Mixture.
No. 1 iron.....	1.52	30 =	45.60
No. 2 iron.....	1.29	22 =	28.38
No. 3 iron.....	1.06	15 =	15.90
Sprue No. 5 iron.....	0.60 44%	53 =	31.80
		120	121.68

121.68 ÷ 120 = 1.014 per cent of silicon the mixture contains.

Grade	3.20	
	384	
67	399	
45	—15	
22 No. 2 iron.....	15	No. 3 iron
	30	No. 1 iron
Malleable scrap, 400 pounds.		
Steel scrap, 300 pounds.	45	

TABLE XXI.

	Silicon, Per cent.	Amount, Pounds.	Silicon in Mixture.
No. 1 iron.....	1.52	32 =	48.64
No. 2 iron.....	1.29	32 =	41.28
No. 3 iron.....	1.06	32 =	33.92
Sprue No. 5 iron.....	0.60 40%	64 =	38.40
		160	162.24

162.24 ÷ 160 = 1.014 per cent of silicon the mixture contains.

Grade	3.20	
	512	
96	512	
64	0	
32 No. 2 iron.....	32	No. 1 iron
	32	No. 3 iron
Malleable scrap, 600 pounds.		
Steel scrap, 500 pounds.	64	

TABLE XXII.

	Silicon, Per cent.	Amount, Pounds.	Silicon in Mixture.
No. 1 iron.....	1.52	26 =	39.52
No. 2 iron.....	1.29	52 =	67.08
No. 3 iron.....	1.06	50 =	53.00
Sprue No. 5 iron.....	0.60 36%	72 =	43.20
		200	202.80

202.80 ÷ 200 = 1.014 per cent of silicon the mixture contains.

Grade	3.20	
	640	
128	616	
76	+24	
52 No. 2 iron.....	26	No. 1 iron
	50	No. 3 iron
	76	

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

The calculations are proved as follows:

TABLE XXIII.

6-ton heat	120		
No. 1 iron.....	30	× 1 =	30
No. 2 iron.....	22	× 2 =	44
No. 3 iron.....	15	× 3 =	45
Sprue No. 5 iron.....	53	× 5 =	265
	120		= 384

TABLE XXIV.

8-ton heat	160		
No. 1 iron.....	32	× 1 =	32
No. 2 iron.....	32	× 2 =	64
No. 3 iron.....	32	× 3 =	96
Sprue No. 5 iron.....	64	× 5 =	320
	160		= 512

TABLE XXV.

10-ton heat.....	200		
No. 1 iron.....	26	× 1 =	26
No. 2 iron.....	52	× 2 =	104
No. 3 iron.....	50	× 3 =	150
Sprue No. 5 iron.....	72	× 5 =	360
	200		= 640

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Since the different irons used multiplied by their grade numbers and added equal the base number from which the calculation is made, the grade must be 3.20, and the silicon contents of the heat is 1.014 per cent.

The three heats shown have the same grade and therefore the same silicon contents, but the amounts of malleable and steel scrap have been increased in the 8 and 10-ton heats. For this reason the 8-ton heat is a higher mixture than the 6-ton heat, while the 10-ton heat is a higher mixture than the 6 or 8-ton heat. The size of the heat being taken into consideration, owing to the fact that the number of square inches of metal exposed to the top blast is not increased in proportion to the depth of the metal, it is necessary to charge a higher mixture as the size of the heat is increased. Therefore while these heats have the same silicon contents, they are each a little higher than the other owing to the amount of scrap used, showing how higher mixtures are made by varying the amount of scrap used.

In calculating heats by this method the amounts of the different irons used depends upon the amount of sprue used, and the remainder obtained from subtracting these two base numbers, determines whether it is necessary to use more No. 3 iron than No. 1 iron or vice versa.

This remainder for the 6-ton heat is —15, which shows that the base number for the sprue is in excess of the base number for the grade of the heat. For this reason it is necessary to use 1,500 pounds more of the No. 1 iron than the No. 3 iron to obtain a certain silicon content for the mixture. This remainder will not be minus unless a large amount of sprue is used, and the sprue being the lowest silicon iron available, it naturally follows that less No. 3 iron must be used to obtain a certain silicon content, and this remainder governs the exact amount.

There is no remainder for the 8-ton heat, as the two base numbers are the same. Therefore the No. 1 and the No. 3 irons must be used in equal quantities. In this case, if no No. 1 and No. 3 irons had been used, the required silicon contents could have been obtained by using the No. 2 iron and the sprue.

This remainder for the 10-ton heat is +24, which shows that the base number for the grade of the heat is in excess of the base number for the sprue. For this reason it is necessary to use 2,400 pounds more of the No. 3 iron than the No. 1 iron to obtain a certain silicon contents for the mixture. By using less sprue it naturally follows that more No. 3 iron must be used to obtain a certain silicon contents for the heat and this remainder governs the exact amount.

These three heats show how carefully and completely this method is devised as since the different grades of iron used in these mixtures, are in exact proportion to each other, the same silicon contents can be obtained whether the two base numbers are equal or there is a remainder with a plus or minus. When the remainder is a plus, the amount added to this number will be the No. 1 iron, whereas if this remainder is a minus the amount added to this number will be the No. 3 iron. Lowering the grade increases the silicon contents while raising the grade reduces the silicon contents.

In the 10-ton heat referred to, the No. 2 and No. 3 irons have been used in large quantities and these piles will be drawn upon the heaviest. If it is necessary to run a higher mixture and finding it impossible to increase the percentage of sprue used, and desiring to use less of the No. 2 and No. 3 irons, a mixture is made up containing No. 4 iron.

The silicon required in this mixture is to be 0.945 per cent. By referring to the heat card we find that the heat

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must be figured at a grade of 3.50 and the calculation is made as follows:

TABLE XXVI.

	Silicon, Per cent.	Amount, Pounds.	Silicon in Mixture.
No. 1 iron.....	1.52	26 =	39.52
No. 2 iron.....	1.29	32 =	41.28
No. 3 iron.....	1.06	30 =	31.80
No. 4 iron.....	0.83	40 =	33.20
Sprue No. 5 iron.....	0.60 36%	72 =	43.20
		200	189.00

189.00 ÷ 200 = 0.945 per cent of silicon the mixture contains.

Grade		3.50		
		700		
128		616		
96		+84		
32	No. 2 iron.....	+26	No. 1 iron	26
		110		
		—30	No. 3 iron	30
		2/80		
		40	No. 4 iron	40
				96

Malleable scrap, 800 pounds.
Steel scrap, 700 pounds.

In calculating the 10-ton heat having a grade of 3.50 the base number is 700 and the base number using 36 per cent sprue is 616. Subtracting 616 from 700 leaves a remainder of + 84. For this reason it is necessary to use 8,400 pounds more of the No. 3 iron than the No. 1 iron. Using 2,600 pounds of the No. 1 iron added to + 84 equals 11,000 pounds of the No. 3 iron, and these two added would equal 13,600 pounds, which is in excess of the 12,800 pounds of pig iron required to make up a 10 ton heat using 36 per cent sprue. By using 3,000 pounds of the No. 3 iron, which amount is subtracted from 11,000 pounds, leaves a remainder of 8,000 pounds, and this amount divided by 2 equals 4,000 pounds of the No. 4 iron. The No. 1, No. 3 and No. 4 irons added equal 9,600 pounds and this amount subtracted from 12,800

pounds equals 3,200 pounds of the No. 2 iron required. The calculation is proved as follows:

TABLE XXVII.

No. 1 iron	26	× 1 =	26
No. 2 iron	32	× 2 =	64
No. 3 iron	30	× 3 =	90
No. 4 iron	40	× 4 =	160
Sprue No. 5 iron	72	× 5 =	360
	200		= 700

the base number from which the calculation is made.

Since the different irons used multiplied by their grade numbers, and added equal the base number from which the calculation is made, the grade must be 3.50 and the silicon contents of the heat 0.945 per cent.

It is not necessary to use irons having the same silicon as were used in calculating the heats shown, and a change in the irons may be necessary to give the proper range of silicon contents for the different heats. Irons having different silicon may be used selecting these in as nearly equal proportion as possible to each other and to the sprue, which also does not have to be figured having 0.60 per cent silicon as a higher or lower percentage can be used as well. The reason that the sprue has been figured at 0.60 per cent silicon in the mixtures shown, is due to the fact that this is a fair proportion for the average run of malleable work.

For a foundry making a light class of castings which will have the silicon in the hard iron between 0.80 and 1.00 per cent the sprue can be used as having 0.80 per cent silicon and be figured as No. 4 iron.

Having selected the grades of iron to be used, a heat card can be made up, showing at what grade the mixture must be figured to obtain a desired silicon content. This card gives the base number for the different grades and also the different percentages, together with the base numbers for the different percentages of sprue and pig iron required for the different size heats.

By this method it is possible to obtain a large range of silicon for any size heat, which makes it universal, as the silicon contents can be raised or lowered for any size heat required.

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If a softer mixture is required than the card indicates, this can be made by using a higher silicon pig iron for the No. 1 iron, making up a mixture as first shown. If a lower silicon mixture is required than the card indicates this can be obtained by leaving out the No. 1 iron, and using the other irons graded as No. 1, No. 2, No. 3 and No. 5 making up a mixture as first shown.

Mixtures can be calculated leaving out any one of the three different grades, and using only two grades, or by leaving out two grades and using only one grade of pig iron with the sprue and scrap. If occasion demands that only a limited amount of the No. 2 iron be used, having determined this amount a mixture can be accurately calculated, using this amount.

Malleable and steel scrap have a certain effect upon the mixture and therefore should be used in proper proportions, and should not be used excessively except in extreme cases and then only for a short period of time.

By making a careful study of the furnace conditions, the mixture can be calculated and varied, so as to overcome the adverse conditions and keep the finished product within the proper limits. The daily analysis of the hard iron test blocks together with their appearance when broken will prove whether the mixture is within the proper limits, and indicate what slight changes are necessary.

With this method it is possible to run a different mixture for the different classes of work being made, which insures a more uniform grade of castings.

Effect of Varying Silicon and Carbon in Malleable Iron Mixtures

By A. L. Pollard, Batavia, N. Y.

It has been the custom, since first malleable iron mixtures were made up by analysis, to consider silicon as the element of prime importance. It is only recently that the effect of carbon has been studied carefully. Professor Touceda has done a very great service to the industry by investigating this subject during the past year.

The writer's attention was first called to this subject by the accident of a very low carbon heat. The test wedges from this proved to have such excellent qualities that it seemed to offer a most interesting field for investigation. A record was therefore kept of the analysis and physical properties of every heat for a period of eight months and the data then correlated to show the effect of varying carbon and silicon.

The physical test used was that devised by Mr. Walker and standardized by Professor Touceda. Wedges 6 inches long and 1 inch wide by ½-inch at the base were cast, and annealed with the regular castings. The annealing was normal and was the same in all cases, the ovens being brought up to 1,650 degrees Fahr. in 18 hours, held at 1,650 degrees Fahr. for 72 hours, and cooled for about 60 hours. The wedges were then placed upon the anvil of a small drop hammer, and were given a sufficient number of 70 foot-pound blows to fracture them.

The hard iron analyzed in every test about 0.175 phosphorus, 0.04 to 0.07 sulphur and 0.20 to 0.25 manganese. These elements therefore do not enter into this discussion. Only the carbon and silicon content was considered in gathering the tests into representative groups. There were of course variations due to improper annealing, shrinks, etc., but these were eliminated, provided the fracture showed the effect conclusively.

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The condensed results are as follows: (Analyses given are for the hard iron).

First Series:—

Carbon 2.30 to 2.40
Silicon 0.90 to 1.00—18 blows
Silicon 0.80 to 0.90—24 blows
Silicon 0.70 to 0.80—30 blows (1 test only).

Second Series:—

Silicon 0.90 to 1.00
Carbon 2.30 to 2.40—18 blows
Carbon 2.40 to 2.50—14 blows
Carbon 2.50 to 2.60— 9 blows
Carbon 2.60 to 2.70— 5 blows (1 test only).

Third Series:—

Silicon 0.70 to 0.80
Carbon 2.64—15 blows (3 tests).

There was very little variation in the appearance of the above fractures. Most of them were dark gray with a lighter rim about 1/16-inch wide. The high silicon and high carbon fractures showed numerous crystals reflecting points of light. All samples were well annealed.

The physical properties as exhibited by the above tables, show uniformly high ductility on low carbon mixtures, and where both carbon and silicon are low the properties are unusually good. The actual number of blows which the low carbon series stood was not affected seriously by wide variations in the silicon content. The higher silicon irons seemed somewhat stiffer.

The series of varying carbon show, at the higher carbons, a great reduction of ductility. The results in this connection were most uniform and seem to give the carbon content an importance which has not been generally recognized.

In recording the above data along with the foundry records showing broken and hard castings, an interesting and unexpected result was observed. The broken work on a line of thin and difficult castings had been running 2.25 per cent, and the lost work around 12 per cent, when making an iron corresponding to the third series given above. As soon as a higher silicon and low carbon mixture was made, both the broken and bad percentages were considerably reduced, the broken averaging 1.50 per cent and the bad 8 per cent. The

writer cannot explain why this change should render the castings less liable to breakage, but believes that the higher fluidity was responsible for the reduction in the percentage of lost castings.

Aside from the technical aspects of this question there is an important economic aspect. With pig iron fairly high in silicon, a larger percentage of scrap can be used on high silicon low carbon mixtures. In a charge initially low in carbon, the silicon seems to have a lesser tendency to burn out. Especially is this fact of value in enabling the use of large quantities of malleable scrap.

Below are given two typical charges with resulting analyses:

HEAT NO. 223.

	Pounds.
Sprue	7,600
Old Mall	1,000
Steel	200
Pig Iron	8,200
	17,000

	Silicon.	Sulphur.	Manganese.	Carbon.
Charge Analysis	1.14	0.041	0.390	2.76
Hard Iron Analysis	1.08	Not determined.	0.210	2.22

HEAT NO. 506.

	Pounds.
Sprue	7,500
Old Mall	300
Steel	200
Pig Iron	9,000
	17,000

	Silicon.	Sulphur.	Manganese.	Carbon.
Charge Analysis	1.17	0.043	0.398	3.02
Hard Iron Analysis	0.93	Not determined.	0.226	2.60

A further economic consideration is that the higher fluidity of the high silicon low carbon heats means less loss in melting, and shorter heats. This greater fluidity is very pronounced.

In general, we conclude that where extreme ductility is desired the low silicon low carbon mixture is best, but for the average line of work a high silicon low carbon mixture will fulfill every requirement. It seems to reduce scrap and add greatly to the economy and ease of operation of the furnace.

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Remarks on the Strength and Ductility of Malleable Cast Iron After the Skin has been Removed

By Enrique Touceda, Albany, N. Y.

Having been requested by your committee on papers to prepare a brief article to be read at this convention on some subject pertaining to malleable cast iron, I do so with pleasure, both for the purpose of meeting this obligation, and of embracing the opportunity to contradict as emphatically as I may, the statement frequently made, that after the skin of a malleable casting has been removed, the remaining metal is of inferior quality, if not absolutely worthless.

A case in point occurs in a recent article entitled "Castings for Specific Needs", written by a metallurgical engineer, and read before an engineering society of Cleveland. Abstracts from this paper were subsequently published in the *Iron Age*, May 21.

Quoting verbatim what he has stated on this subject, I would like to make answer to him at this time, and to those who erroneously hold the same view. His words are as follows: "Where still additional strength is required and considerable toughness, the malleable casting offers an excellent solution, especially where castings are small. The malleable casting should not be confused in value with steel forgings, as the only part that is at all ductile is the outside skin. Malleable castings are about twice the value of gray iron castings."

It is a well-known fact that the softest and most ductile constituent in any iron product, is ferrite—carbonless iron. If, through the aid of the microscope, one is shown a specimen of iron or steel that has been properly polished and etched for that character of examination, and it is seen that in the structure ferrite predominates, it can be predicted that the material from which the specimen was taken is soft and ductile, directly in proportion to the amount of ferrite present. If the structure

is wholly ferrite, and this is uncontaminated by slag or free carbon, it can be predicted that the metal is of maximum softness and ductility.

The structure of good wrought iron consists practically of ferrite, due to its containing but an inappreciable amount of carbon, but the uniformity of the structure, as can be seen by reference to the photo-micrograph, Fig. 1, enlarged 63 diameters, is somewhat interfered with by the presence of slag particles that cannot be entirely removed from the iron during the process of manufacture.

It must be conceded that commercial wrought iron is both soft and ductile, and that its structure consists practically of ferrite, throughout which are irregularly distributed particles of slag, so that if we obtain some other product of similar structure, aside from the fact that for the particles of slag there is substituted some other impurity equally inert, we should logically expect to have a product of similar physical qualities.

Before entering into a description of the structural composition of malleable cast iron, we will consider briefly the malleable iron process. This consists first, in melting in an air furnace, a properly proportioned mixture of gray pig iron, and sprue from some previous heat, and refining the bath until enough silicon has been removed from the iron to force all of the carbon to remain combined in the resultant product, to the end that the iron in the castings will be white, with the accompanying hardness and brittleness incident to this condition. Second, the placing of these castings in iron pots, where they are surrounded with an oxidizing packing; the pots being then placed in ovens to be heated to redness for numerous days.

Through this heat treatment, the extremely hard carbide of iron of the white iron casting, is broken up into two very soft constituents, carbonless iron (ferrite), and free carbon which contaminates it; while coincident with this transformation some of the carbon is removed from the casting; both factors serving to convert the hardest possible product into one of the very softest.

Coming now to the structural composition of good malleable iron, it must be seen from the description of the process, that

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if the object of the anneal is to separate the hard carbide of iron into its two constituents, iron and carbon, that the structure *must* consist of ferrite and free carbon, failing which, the anneal has not been properly accomplished. It may be accepted then, that the structural composition of properly annealed malleable iron is made up wholly of ferrite, but with the exception of the ferrite in the rim, all of this constituent is contaminated with more or less free carbon, the preponderating amount of ferrite containing but very little, and the lesser amount containing it in

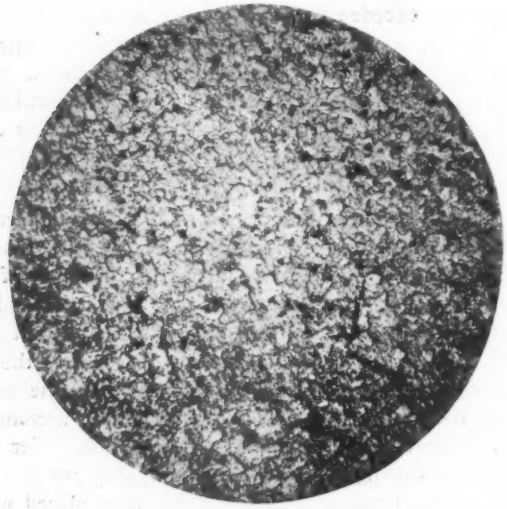

FIG. 1—MICRO-PHOTOGRAPH OF THE CROSS SECTION OF A WROUGHT IRON BAR

highly concentrated form, these carbon patches, as they can be appropriately called, being uniformly distributed throughout the area of the section, as can be seen by reference to Fig. 2, taken at 63 diameters.

In short, with two exceptions, if the slag of wrought iron and the free carbon of malleable iron be left out of consideration, the structural composition of wrought iron and malleable iron are identical. One of the exceptions is that the ferrite

of the malleable iron is higher in silicon than that of the wrought iron; but if the proper authorities be consulted it will be seen that they state, that such an amount of silicon as may be found in commercial malleable iron does not render the ferrite less ductile, nor does it have an influence to render more coarse the crystallization. This then can be set aside as having no bearing on the case. The other exception results from the presence in the ferrite of the contaminating free carbon, which is present in too small an amount in a great part of the ferrite

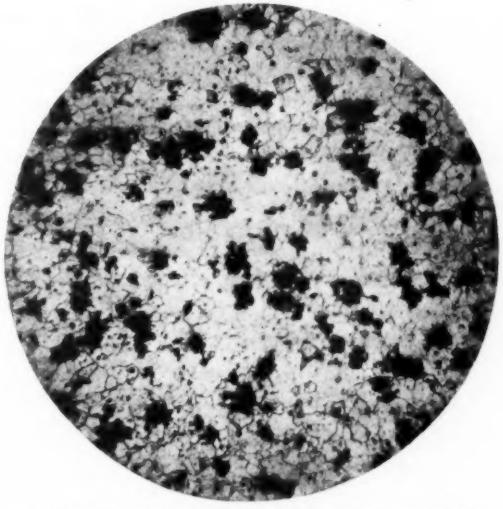

FIG. 2—MICRO-PHOTOGRAPH OF THE CROSS SECTION OF A MALLEABLE IRON BAR

to affect its true physical properties to any appreciable extent, but which I anticipate must lessen its strength and ductility where it occurs in the ferrite in concentrated form, as shown in the patches referred to.

What I desire to make plain at this time, however, is the fact that if the two steps in the malleable iron process have been properly conducted, even if in a casting there be a section three inches square, it will be found that the structure of this

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section is uniform throughout; which fact I have proven to my complete satisfaction on numerous occasions.

How the Skin Differs From the Core

Let us now take up the question of the so-called skin of malleable iron castings, and see in what particular this skin differs from the rest of the metal in the casting. If the annealing process has been arrested at the exact moment when the last trace of free or pearlitic cementite in the casting has been broken up into ferrite and free carbon, there will be seen under magnification, around the edge of the casting a rim about 1/32 inch deep of practically carbonless iron, due to the perfect elimination of the carbon to this depth. As a matter of fact such a rim as I describe exists in any piece of rolled steel or steel casting, so that in this particular a malleable casting does not differ in this respect from rolled steel or steel castings.

The structure in the balance of the section is very uniform throughout, except that it can be noticed that the patches of concentrated carbon increase slightly in size as the center of the section is approached, the increase being very slight indeed.

If we now take a ¾-inch round test bar, and calculate the area remaining after the rim has been machined off, and then the area of the metal in the rim, it will be found that the first amounts to 0.442 of a square inch, while the latter amounts to 0.07 of a square inch; the metal in the rim being 15.8 per cent of that in the core, as the rest of the metal is sometimes designated.

It has been pointed out, that the structural composition of the rim as a rule is ferrite, uncontaminated with free carbon, and it is a well-known fact that annealed ferrite will not exceed in strength more than 50,000 pounds per square inch. If the amount of metal in the rim is but 15.8 per cent of that of the rest of the bar, its strength would have to be very much higher than the strength of annealed ferrite in order to bring the strength of the bar as a whole to 41,000 pounds per square inch, the average strength of commercial malleable iron. Assuming for the sake of illustration, that the metal remaining after

the rim has been machined off will stand 30,000 pounds per square inch, which is certainly far from being worthless material, the metal in the rim must stand as high as 98,838 pounds per square inch, in order to bring the bar as a whole to a strength of 41,000 pounds per square inch, the average strength of commercial malleable iron. Also 98,838 pounds per square inch corresponds to the strength of a 0.50 per cent carbon steel. If the statement is correct, that after the rim has been removed the remaining material is very inferior and lacks ductility, then the figure that I have placed as its strength (30,000 pounds per square inch) is too high, and the metal in the rim must be called upon to stand a strength in excess of 98,838 pounds per square inch, that is, a strength equal to a 0.60 per cent carbon steel.

An elongation of 10 per cent in 8 inches is by no means uncommon in good malleable iron, and if the above remarks on the relative strength of the metal in the rim and core does not make the statements I am questioning absurd enough, let us dwell for a moment on the condition that must exist in a malleable test bar that yields an elongation in 8 inches of 10 per cent.

It is conceivable, and a fact that must be acknowledged, that a rim of metal having a strength in excess of that in the core, can add greatly to the final strength of the bar, but how under the sun can the metal in the rim affect the elongation, unless its ductility be less, not greater, than the metal in the core? If it be of less ductility, then it will start to check as the limits of its capacity to stretch without fracture is reached, and the metal in the core will continue to stretch until the bar breaks; but if, as is claimed, it is more ductile than the metal in the core, then the metal in the core will stretch until it can no longer do so, when the metal in the core breaks, and that in the rim likewise, for obvious reasons, though it must be admitted that the metal in the rim had not at the time reached the limits of its capacity to stretch.

If my reasoning is correct, and I feel quite confident that such is the case, any record of elongation on a malleable iron test bar, expresses in exact terms the elongation of the metal

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in the core only, as the metal in the rim is capable of further stretch. Records of elongation then, on malleable iron test bars, are a direct measure of the ductility of the metal in the core of the bar.

I do not wish to be placed in the light of questioning the absolute good faith of the gentlemen who are responsible for the statements that I am criticizing, and I believe that I know the basis through which they have arrived at their conclusions. The trouble can be laid to defects in the test bars from which their data has been obtained.

Defects in Test Bars

The writer, particularly during the past few years, has had a great deal of experience in the making of physical tests of malleable cast iron, and he has noticed that defects nearly always exist in bars such as are usually made for tensile test, due to unsoundness caused by shrinkage, or faulty contraction as the case may be. Such defects obviously are in the majority of cases located at the center of the section of the bar, and nearly always at the central region of the bar's length.

I wish to stick to my brief, and not enter into matters pertaining to the correct character of test bar for the making of physical tests of malleable cast iron, but it is necessary for me to point out certain facts that tend towards results that are misleading.

Many test bars are made with a reduced section, for the double purpose of enabling the grips of the machine to better hold the specimen, and of forcing the bar to break outside the grips. A bar cast in this manner is nearly always defective due to the inability of the iron to set normally. First, the liability of a shrink existing at the fillet, and second, to the fact that the tightly packed sand around the reduced section of the bar, acts as a core to prevent the normal setting of the molecular structure in the region of the center of its length.

Where bars are of uniform section throughout, and either round or square, defects are of frequent occurrence at the central portions of the bars. Now, when experiments are made to determine the difference in strength between skin and core,

by the time the finishing cut is made at least 1/16 inch of the stock has been removed all around the bar, and this represents perhaps 30 per cent of the original area, and at times more is removed under the belief that the skin exceeds this amount in depth. If the region around the central portion of the test bar is unsound, due to any cause, what chance is there of arriving at correct conclusions as to the relative strength of metal in skin and core?

Another bad practice in the making of such experiments lies in the failure to make the surface of the bar smooth after the final cut. When a bar is machined for test, the surface should be gone over with a Swiss file or very fine emery cloth before the bar is removed from the lathe, failing which I do not believe the results to be trustworthy.

As before stated, the microscope shows no appreciable difference in structural composition in different parts of the core of pieces of good malleable iron, be the bar as large as 2 inches square, and the sole difference between the structural composition of the skin and core, is that there is an absence of free carbon in the ferrite of the skin.

If there is any reason why there should exist a great difference in strength between the metal of the skin and core, surely there should be seen some tangible evidence under the microscope. When such cases happen in steel or gray iron, the microscope immediately makes manifest the cause, and there is no difficulty whatever in making plain the reason for the alteration in strength, as there will be seen a difference in grain-size between the parts, in structural composition, in unsoundness or oxides. In order to go into this matter along lines that may appeal to you as being more satisfactory than a mere discussion of the situation, we have made some physical tests conducted under conditions of extreme severity as compared with the regular tensile test.

This was done first, because the greater part of malleable iron castings are subject to dynamic stresses; that is, subjected to great abuse in service; second, in the selection of a test bar where any unsoundness will be restricted to a part of the bar

that will not affect the correctness of the results; and third, for a reason that will appear later.

The form of the test bar is a wedge 1 inch wide throughout and 6 inches long; ½ inch thick at the base, and tapering to 1/16 inch at the top. This wedge, when tested under a specially designed test hammer, has its thin end first bent slightly over by hitting it a few slight blows with a hand hammer for the purpose of facilitating the curling up of the bar when it is subsequently placed on the anvil of the test hammer to be struck repeated blows until fracture takes place. In testing the bar, it is held upright on the anvil, when the hammer-weight, delivering a seventy-foot pound blow, is allowed to fall on it. If the metal is ductile and strong it will curl up more and more

FIG. 3—FOUR TEST WEDGES OF MALLEABLE IRON

until failure takes place, and the number of blows required to produce fracture and the amount of the curl become a direct measure of the strength and ductility of the metal.

In Fig. 3 can be seen four such test wedges that have been struck repeated blows, the blows being stopped the moment it was seen that fracture had commenced. I will refer more specifically to this photograph later as at the present time I simply desire to illustrate the manner in which they curl up under test.

A pattern was made for a wedge of the above dimensions, and another was made of the same length and width, but 5/8 inch thick at the base, and 3/16 inch at the other end. When 1/16 inch of metal is planed off of the two 1x6-inch faces of the latter wedge, we have one that corresponds exactly in size with the other, so that through the aid of these two patterns, and the machining of the larger as described, we can secure wedges of

the same dimensions, one with the skin on and the other with 1/16 inch of the surface metal removed. We will see later just what the removal of this amount of metal means.

The following are the results of the tests, the weight delivering a blow of 70 foot-pounds when the wedge starts to curl, and a slightly greater force after each succeeding blow:

Unmachined wedges.	Machined wedges.
Afternoon heat of June 3rd.	
Average of 4 tests.	Average of 4 tests.
18.5 blows.	13.2 blows.
Afternoon heat of June 4th.	
Average of 4 tests.	Average of 4 tests.
29.75 blows.	26.3 blows.
Morning heat of June 6th.	
Average of 4 tests.	Average of 4 tests.
19.75 blows.	21.2 blows.

Here we have one case where the machined wedges actually stood a better test than the ones with the skin on, but setting this aside as unusual, which I believe would prove to be the case, can anyone state after the physical tests herewith presented that malleable iron with absolutely all its skin removed is neither ductile nor trustworthy?

Fig. 3 shows four of these machined wedges that have stood 24, 24, 21 and 20 blows of 70 foot-pounds respectively, and these I am bringing with me to the convention for inspection. Please remember that the heavy blow delivered by this weight is falling on very light sections that vary in size from 1/16 x 1 inch to the largest of 7/16 x 1 inch, at which section they usually fail. Examine these wedges, please, and then decide as to whether the extreme fibers on their tension side have stretched. Could any metal other than a very ductile one stand such treatment prior to failure?

We now come to the third reason for the selection of this type of bar for the test. Calculation will show that after 1/16 inch has been machined from each side of the wedge, about 20 per cent of the stock has been removed from the base; about

66 per cent from the thin end section, and about 26 per cent at the section where failure usually takes place. If this is not testing the core of the metal with a vengeance, I am open to suggestions that may show a better method of procedure, or a fairer one. I also desire to state that these wedges were cast from regular iron as made from day to day, and that they received no treatment other than what the regular run of commercial castings made at this plant are given.

I have individual cases of machined wedges that have stood as high as 29 blows.

Through the courtesy of a manufacturer of steel castings I had some steel wedges cast from the same pattern as that from which the malleable iron ones were made, and these stood 19, 21 and 23 blows respectively, when tested in exactly the same manner.

In conclusion would state that good malleable castings possess virtues that have not received the recognition they deserve when their unique characteristics are considered. When cheapness, soundness, ease of machining, freedom from blow-holes, ability to stand abuse in service, marked stiffness combined with ductility are considered as a whole, this casting has no competitor.

Bad castings made by any process are worthless. The metallurgy of malleable iron, in my opinion, is more complex and more difficult than that of any steel or iron process. Owing to this fact particularly, the industry has suffered greatly through the sale by some of a product that has served to place doubt in the minds of many as to the true physical characteristics of these castings. It has likewise suffered considerably through careless statements made by engineers and others who have possibly had an unfortunate experience in their use through dealing with those whose product is not up to standard, or who have failed to give their investigation the attention it deserved.

Malleable Iron—Its Manufacture, Characteristics and Uses

By J. P. Pero, East St. Louis, Ill.

We undoubtedly owe to the great Frenchman, Reaumur, the information we now possess on the softening of cast iron. In 1722, he states, in regard to the softening of cast iron, that heating iron castings embedded in red oxide of iron softens the metal much more rapidly than any other method which he had tried. This we believe was the first information regarding the production of material similar to that now called malleable iron. In 1804, an Englishman, named Samuel Lucas, in some way was able to obtain a patent on the process and the industry practically begins from that date. In this country Seth Boyden began using this process in Newark, N. J., in 1826. In 1828, the Franklin Institute offered a medal for the best piece of annealed cast iron, the pieces to be twelve in number, and the medal was awarded to Boyden. Thus began the manufacture of so-called malleable iron in the United States.

Notwithstanding the fact that the industry in this country is therefore less than a century old, it has grown to enormous proportions, there being now in the United States about 250 different firms producing malleable iron and producing a total output approximating 1,000,000 tons per year. For some reason the industry is almost exclusively an American one, malleable iron being manufactured in Europe only on a very limited scale, its use over there being confined principally to very light, intricate castings, although there are a few notable exceptions in which European practice is similar to ours.

The malleable iron industry has made its most rapid growth in this country in the past twenty years, during which time it has almost entirely replaced the use of cast iron, in freight-car construction and in the manufacture of agricultural implements. It is now also being used very extensively in the manufacture of automobiles, in stoves and ranges and

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countless other industries. The difference between malleable iron and cast iron is due to the difference in the proportions of the various chemical elements and to the heat treatment given malleable iron in annealing. In the manufacture of malleable iron, the first essential is to secure the proper grade of pig iron, the analysis of which will have to vary more or less with the nature of the work, whether heavy or light.

How the Iron is Melted

This iron, with the desired percentage of sprue and scrap, is charged into the air furnace and melted with any high-grade coal which is low in sulphur and will carry a long hot flame. When the metal is in the molten state, a test is made to determine whether a sufficient amount of silicon and carbon has been oxidized out to produce a white iron casting, for it is essential to the manufacturer of good malleable iron castings that none of the carbon appear in the castings in the graphitic form, but that the castings be a perfect white and free from any mottle.

Owing to the lower carbon and lower silicon content of the malleable mixture, the melting point is considerably higher than is the case in cast iron and as the lower carbon, silicon, phosphorus and manganese content makes malleable iron less fluid than gray iron, the metal must be poured very much more rapidly and at a higher temperature, requiring greater skill on the part of the molder, to prevent misruns and to avoid washing or blowing due to the rapid influx of the metal.

The use of the cupola in the manufacture of malleable iron castings is practically obsolete, being used only in a very few shops making the lightest kind of castings, the cupola having been replaced almost entirely by the air furnace and in some few shops by the open-hearth furnace. The use of the cupola was abandoned because of the uncertainty in the results obtained, although the cost of melting, both as far as fuel consumption and maintenance are concerned, is very much lower in the cupola than in either the open-hearth or air furnaces.

Owing to the fact that malleable iron runs lower in silicon, phosphorus and manganese than gray iron, it is much

more liable to shrink and crack than gray iron. The initial contraction in a malleable iron casting is about double that of cast iron, averaging about ¼ inch to the foot. On this account, great care must be used to avoid shrinkage flaws in castings, due to unequal cooling of the casting. An expansion of about ⅛ inch to the foot occurs in annealing malleable iron, so that in making patterns for malleable castings, the same shrink rule is used as for patterns for cast iron work.

The gating must be entirely different and, as a rule, it is a good plan to have the malleable iron foundry which is to furnish the castings gate the patterns.

Difference Between Shrinkage and Contraction

Do not confound the terms "shrinkage" and "contraction" as used in this description. Contraction is the term used to designate the difference in dimensions between the pattern and casting, while the term shrinkage is intended to designate the drawing away of the fluid iron from the heavier section by the lighter sections, due to the lighter sections solidifying more quickly than the heavier and naturally drawing or feeding from the more fluid iron in the heavier section.

Cracking is the result of strains which are caused by unequal expansion and contraction and is frequently due to abrupt changes and even to slight changes in sections. The cracks generally show when the casting is taken from the sand, but frequently the castings show no crack until after annealing, showing that the shrinkage strain existed originally, but was latent until acted upon either by expansion under heat of annealing or contraction during cooling process of annealing.

Shrinkage flaws can best be avoided by designing the castings of as nearly uniform sections as possible. Abrupt changes of section should be carefully avoided, but where such changes in section cannot be avoided, shrinkage may be overcome by the use of chills on the heavy sections which tend to accelerate the cooling of the heavy section, and in this manner bring about a more uniform solidifying and cooling of the varying sections. Shrinkage is also overcome by gating on the light sections as close as possible to the point at

which the heavy and the light sections join. The gates should be supplied with shrink balls sufficiently heavy to feed the shrinkage. Care should be taken to gate into the light section rather than the heavy, for then the gate and shrink ball will serve the double purpose of feeding the shrinkage, occurring first in the light section, which would otherwise be drawn from the heavy, also retarding the solidification and cooling of the light section, in order to have these actions more nearly simultaneous in both the heavy and the light sections.

After the castings have been poured, they are broken from the gates in the usual manner and sent to the cleaning room where the sand is removed by tumbling, and in cases where the castings are too frail to permit their being tumbled, the sand is removed from them with a sand blast or by pickling the castings in a solution of sulphuric acid.

When the sand has been removed, the castings are inspected and fettled, by which term we mean that any projecting fins, gates or rough places are chipped off with a hammer which can be readily done while the castings are still in the hard iron state.

The Annealing Process

The good castings are then sent to the annealing room where they are packed in annealing pots which consist of a heavy malleable iron frame usually about 18 x 24 inches and 12 inches deep, these frames or rings being placed one upon the other as they are filled until the tier of pots or frames is from 4 to 6 feet high. In these rings the castings are carefully packed, so as to prevent their warping during the annealing process. The spaces between the castings are filled with a packing, consisting usually of rolling mill scale or crushed slag, but generally a mixture of both these materials. The joints in the rings are then carefully luted up with clay, as are also the tops, so as to exclude the air from the castings. The pots are then trucked from the packing floor to the ovens, the oven doors are walled up and they are then fired until the pots show a good bright red heat, the proper annealing temperature being between 1,300 and 1,500 degrees Fahr. After

this temperature has been obtained in all parts of the oven, the drafts are closed and the oven permitted to soak, the annealing temperature being maintained for about 72 hours. The oven is then cooled as slowly as possible and when the pots are black, they are removed and dumped, each potful of castings being thoroughly tested to see that the castings have been subjected to the proper temperature, and are properly annealed before being sent to the soft iron tumbling room where they are again tumbled.

The time consumed from the time the castings are placed in the oven until they are ready to be taken out will vary with the size of the ovens, but usually averages from about four to eight days.

Until recently it was considered absolutely necessary to use an iron oxide as packing; in fact, malleable foundries were put to considerable expense in buying mill scale for this purpose and a few years ago it was a very common practice to spread the packing thinly over the floor and sprinkle it with a solution of sal-ammoniac, which caused it to rust quickly, thus furnishing the oxide considered necessary.

A common practice now is to use the slag obtained from the skimmings of the melting furnaces, which slag is washed and ground in a wet tumbling barrel, in order to obtain the shot iron mixed with it in the skimming process. This material is frequently used alone as packing, but sometimes is mixed with mill scale. Some foundries are using sand as packing and still others are annealing in muffled ovens without either pots or packing of any kind.

After being tumbled, any castings which have become badly distorted in the annealing ovens are straightened either by hand or under the drop hammer. In some cases, the fins are ground and the finished castings sent to the shipping room for distribution to the customer.

A satisfactory quality of malleable iron should show a tensile strength of from 35,000 to 55,000 pounds and in some cases 60,000 pounds per square inch with an elongation of from 3 to 8 per cent in 2 inches.

Its greatest advantage is the fact that the metal is not subject to crystallization or fatigue, but will stand as severe a test after twenty or twenty-five years of use as it will when originally made, no matter how great the vibration may have been to which it has been subjected.

If proper care is used in its manufacture, it should also be quite free from internal flaws, such as blow holes or shrinkage flaws, and the metal, while it will stand considerable abuse and distortion before breaking, is much more rigid and will resist the tendency to become distorted to a greater extent than either drop forgings or steel castings of the same sections.

Malleable iron also resists rusting or corrosion very much better than either wrought iron and steel, running only slightly below cast iron in its resisting qualities to oxidation.

Annealing Heavy Sections

There is a widely prevailing belief that malleable iron can be annealed only in light sections and that when sections over ⅜ inch in thickness are required, difficulty will be experienced in properly annealing it. The facts are that there is no limit to which malleable iron can be annealed, providing the manufacturer has used the proper care in handling his mixture, so as to permit the casting being free from mottles or graphitic carbon in the hard iron state.

Owing to the fact that the heavy sections cool more slowly than the lighter ones, the metal for heavy castings must run lower in silicon and carbon, so as to retain all the carbon in the combined form in the heavy sections. When this is done, the metal becomes less fluid and increasingly difficult to pour into light work and for that reason, it is not practical for the manufacturer of malleable castings to make both heavy and light castings from the same mixture, but where a specialty is made of heavy castings or where the mixture is run especially for heavy work, no difficulty need be or will be encountered in annealing the castings through and through, as all that is necessary to anneal them is to bring the castings up to the proper temperature, in which no difficulty is experienced as it is manifest that when the annealing pots, which

are usually 18 to 24 inches in thickness, are heated through, a heavy casting will be heated through just as readily as a lighter one.

What occurs in the annealing process is not so much a chemical change as a change in the nature of the carbon. A small amount of carbon, it is true, is oxidized from the surface of the casting, but most of it is changed to the graphitic form. Examined under a microscope, the little particles of graphite will appear surrounded by and contained within cells of pure iron. The structure of the cells is not broken by these little particles of carbon, as it is in the case of cast iron, where the graphite is in the shape of a crystal, breaking up the cells of pure iron and weakening the structure.

The cells of iron within which the particles of graphite are contained are practically wrought iron or rather steel, as a small percentage of the carbon will still be left in the combined form. This accounts for the great strength as well as the stiffness of malleable iron.

The graphite contained within the cells gives malleable iron when broken a bluish black color. A very thin section of a lighter color will usually appear around the edge. This skin should not be much thicker than a finger nail and is caused by the fact that on the surface of the casting the carbon has been almost entirely removed, having been oxidized out by the oxide of iron used as a packing in the annealing process with which the castings were in contact while being annealed.

There is a widespread belief that this bright rim around the outer edge of malleable castings indicates the depth to which it has been annealed, but such is not the case; in fact, where this bright edge is too heavy, it is often an indication of poor iron, iron which has been over-oxidized in either the melting or annealing process.

As stated before, it is important in designing a casting for malleable iron to keep the distribution of metal of as nearly uniform thickness as possible, relying upon ribs to give added strength where additional strength is required.

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If the consumers of malleable iron castings would co-operate a little more closely with the malleable iron foundrymen in the designing of their castings, much good would be accomplished, as frequently the failure of malleable iron castings is largely due to their being improperly designed, causing shrinkage flaws or undue strains which have weakened the castings. Co-operation of this kind would not only result in better castings but in cheaper ones, as it would in a large measure obviate one of the principal sources of loss in the malleable iron foundry, due to cracked castings, cracking being caused by unequal strains while cooling in the mold.

Specifications for Malleable Castings

A great deal has been said and written in the past few years with regard to specifications for malleable iron castings and a great many of the railroad companies, particularly, are now making rigid specifications as to tensile strength and elongation, etc., specifying in numerous instances that one casting in every one hundred shall be furnished by the manufacturer for test purposes and that, if desired, the purchaser may cut a test piece from the casting which shall come up to certain requirements as to tensile strength and elongation. Any well annealed piece of malleable iron will readily come up to specifications as to tensile strength and elongation. The essential point is to determine whether the castings have been thoroughly annealed. An annealing pot-full of castings may contain castings from half a dozen different heats which in turn may require as many different temperatures to properly anneal them. Again, it is a difficult matter to get the heat uniformly distributed throughout the annealing oven. It is not uncommon, therefore, in malleable practice to find two castings which are lying side by side in the annealing pot, one of which is thoroughly annealed and the other still brittle, hard and unfit for use. It also is not an uncommon occurrence to find a malleable iron casting 2 or 3 feet in length, one end of which is thoroughly annealed while the other end is still brittle and unfit for use.

Any specifications, therefore, which rely upon the testing of only an occasional piece will not give the consumer of

malleable iron the necessary safeguard. By far the best precaution is to have a test lug cast upon every piece, which can be broken to determine whether the malleable casting is thoroughly annealed without in any way injuring or destroying the efficiency of the casting.

Castings of large size or of any unusual length should have at least two test lugs on them and, in exceptional cases, three test lugs might be desirable.

Some of the railway companies have begun to recognize this fact and are today simply specifying that castings shall be true to pattern, free from shrinkage flaws and other defects, with a test lug cast upon every casting at a point where it will not interfere with fitting points and that the test lug when broken shall show a good quality of malleable iron, thoroughly annealed. This is the test prescribed also by practically all of the railway specialty companies who have probably given the use of malleable iron more careful study than any other class of consumers.

Nearly all malleable foundries keep a record of the chemical analysis of each heat, and also keep records of tensile strength and elongation, as shown by test bars made from each heat especially for this purpose. These records showing the average analysis and the average tensile strength and elongation, together with the test lug showing thorough annealing, are positive assurances of the quality of the iron.

I have in a general way tried to explain the process of manufacture of malleable iron, not touching details of foundry practice which are similar to gray iron, simply pointing out briefly the principal features of difference between the two kinds of iron, and have purposely avoided going into the finer details of manufacture as being too large a field to attempt to cover in the limited time and space at my disposal.

XUM

Researches in the Annealing Process for Malleable Castings

By Oliver W. Storey, Madison, Wis.

At the 1913 meeting of this Association a paper was presented by E. L. Leasman on "A Study of the Annealing Process for Malleable Castings". This work was carried out under the author's direction at the Chemical Engineering Laboratories of the University of Wisconsin. In his work Mr. Leasman investigated the influence of the following variables upon the structure of malleable iron.

1.—Packing materials.
2.—Temperature of annealing.
3.—Time of annealing.
4.—Rate of cooling.

From the results obtained in that work the writer has been able to make a more extended investigation of the exact nature of the reactions occurring in the annealing of the white iron. The results of this investigation are presented in this paper. A detailed account of the earlier experimental work is given by the writer in an article in *Metallurgical and Chemical Engineering* published in June, 1914.

The amount of malleable iron produced annually in the United States exceeds 1,000,000 tons. These statistics show that this process holds an important place in the iron and steel industry. But has it received the scientific attention that an industry of such importance should receive? Judging from the amount of literature available the answer is decidedly in the negative.

Secrecy of Malleable Practice

Owing to the secrecy which has characterized the process in the past, little has been published. The pioneer manufacturer in this country, Seth Boyden, of Newark,

N. J., experimented with the process and also recorded his experiments, although he did not discover the underlying principles involved. He deserves special credit since his experiments were made at a time when scientific experimentation on industrial problems was frowned upon.

No one has done more to advance the industry than your former secretary-treasurer, Richard Moldenke. His book, "The Production of Malleable Castings," and his careful studies of the process, the results of which have been presented before this Association from time to time, have been of inestimable value to the industry.

The method used for the production of malleable iron is fairly uniform throughout the United States. The hard white castings, of suitable analysis, are annealed at a red heat for about 60 hours and cooled slowly.

The products of various foundries differ slightly. The inner core is the same in all cases, consisting of pure iron or ferrite, throughout which are scattered the globules of temper carbon. The outside or shell structure varies from one of pure iron to a high carbon steel. The practice at each plant will determine this structure. One of the objects of this research was the determining of the variables which influenced this shell structure.

The four variables mentioned will influence the structure of malleable iron during the anneal. It is understood that the composition of the hard casting is of primary importance in determining the correct annealing temperature, but was not investigated in this research.

Annealing Results

The results of the research, as given by Mr. Leasman, may be summarized as follows:—

1.—Packing Materials.

a. The packing material does not influence the interior of "black heart" malleable cast iron.

b. The ordinary packing materials do not directly affect the skin structure by chemical action.

c. A loose packing material, allowing a free circulation of oxidizing gases, will result in a carbonless rim.

d. A slightly oxidizing atmosphere will result in a steely rim.

e. A neutral atmosphere will result in a rim having the same structure as the interior.

f. A slow rate of cooling will tend to result in a rim having the same structure as the interior.

2.—Temperature of annealing.

a. No annealing could be observed below 670 degrees cent.

b. The higher the temperature of the anneal (above 670 degrees Cent.) the shorter the time necessary to secure a complete breakdown of the white iron.

3.—Time of annealing.

a. This factor is dependent upon the temperature of annealing.

4.—Rate of cooling.

a. A fast rate of cooling after annealing results in a steely structure.

b. The critical cooling range is between 700 and 775 degrees Cent.

c. If the rate of cooling is sufficiently slow in the critical range all of the carbon will be precipitated.

d. If the carbon is entirely precipitated in the critical range the rate of cooling below 700 degrees Cent. has little effect upon the iron.

Discussion of Conclusions

It has been shown by a number of investigators that in case-carbonizing steel the carbon is generally carried to the steel in the form of a gas—carbon monoxide—and that there is no direct union of the iron and carbon when in contact. In this research it was shown that the carbon left the malleable iron as a gas and that the surface was decarbonized as a result. This is the reverse of the carbonizing process. It is also known that while carbon monoxide

will carbonize iron, carbon dioxide will have the opposite effect and decarbonize it.

It was shown that all of the packing materials generally used at the present time are inert chemically with reference to the castings. Instead of the chemical influence of the packing material being of importance in determining the skin structure of the malleable, its physical properties, method of packing, atmosphere and temperature of the furnace are important in determining the skin structure. On the other hand, the interor or black heart is not dependent upon the packing materials.

If the hard castings are loosely packed in a coarse material it will be seen that the furnace gases will circulate readily throughout the containers. On the other hand, if the castings are solidly packed with a finely ground material like fire clay, there will be but little circulation of the furnace gases.

If a furnace is run so that there is a large excess of oxygen in the products of combustion, the relative amount of carbon dioxide to carbon monoxide will be large. There will then be a preponderance of oxidizing gases which will decarbonize the surface of the malleable. The same reactions occur if tools are heated in a muffle furnace where too high a percentage of oxygen exists—the carbon is burned from the surface and the exterior of the tool will be soft.

If an annealing furnace is run so as to obtain a large proportion of carbon monoxide the furnace atmosphere is one which will prevent the decarbonization of the hard castings. In considering these reactions it is well to note that at the lower temperatures 700 to 800 degrees Cent., the equilibrium between the carbon monoxide and dioxide is such that the latter is formed in preference to the former while at the higher temperatures the reverse is true.

If the atmosphere of the furnace is highly oxidizing and the castings have been loosely packed in a coarse material, the surface of the castings will be subjected to a decarbonizing action which will quickly result in a carbonless rim. Such a rim of pure ferrite is seen in Fig. 1.

If the opposite conditions are true, that is, if the castings are covered by a closely packed material and are subjected to an atmosphere which is only slightly oxidizing, only a small amount of carbon will be removed from the skin and a steely rim will result as in Fig. 2.

Where a carbonizing atmosphere is maintained as when the casting is annealed in a case-carbonizing mixture, the rim structure of Fig. 3 is obtained. In this the excess iron carbide remains, resulting in a hard rim.

Specimens Annealed in Molten Brass

Specimens were annealed in molten brass and consequently were not subjected to any gaseous action. These showed a fracture consisting entirely of ferrite and temper carbon which extended to the outside of the specimen. Not a trace of the steel edge was visible.

In commercial work various results are obtained from the steel rim of Fig. 2 to the pure iron of Fig. 1. More often the structure shown in Fig. 4 is obtained. In this the outer rim of ferrite and inner black heart are separated by a layer of steel. This plainly shows the decarbonizing effects of the furnace gases on the extreme outer portions.

In practice it is often desirable to obtain a hard wearing surface while at other times a tough rim is wanted. By varying the conditions of annealing the necessary rim structures may be obtained.

In malleable cast iron the black heart should consist of ferrite and temper carbon with no combined carbon present. In the white casting all of the carbon is present in the combined state as the carbide, Fe_3C. Such a white iron is shown in Fig. 5. The white areas consist of excess iron carbide, while the dark areas of pearlite consist of fine plates of iron carbide and ferrite. The annealing process results in a complete breakdown of this carbide into its elements. To accomplish this it has been found necessary to heat the hard casting containing the combined carbon to a red heat, 750 to 900 degrees Cent. The reaction is not simultaneous,

but generally requires about 60 hours after which the iron must cool slowly, covering another long period of time. The time required to bring the oven to heat is immaterial. How long should the anneal require; what is the most suitable temperature; what is a satisfactory rate of cooling and what are the reactions involved?

Silicon and Manganese

In malleable iron two elements are present which are important in determining the variables mentioned, namely silicon and manganese. As is known, manganese tends to keep carbon in the combined state and retards the dissociation of the iron carbide. Silicon has the opposite effect.

Silicon also has another important effect as a result of its tendency to prevent combined carbon. The higher the percentage of silicon present the higher the temperature below which carbon and iron may be entirely decomposed.* This means that by increasing the silicon content of malleable iron the easier will be the breakdown of the iron carbide. The amount of silicon, of course, is limited by the tendency to form gray iron.

In studying the process it was found that the rate of cooling was important. By cooling rapidly, that is, requiring about 20 hours for the cooling of the specimen, it was found that the resulting malleable was brittle and hard. A microscopic examination showed it to consist of a high carbon steel. The micrograph, Fig. 6, shows specks of temper carbon surrounded by pure ferrite in a background of pearlite. A slower rate of cooling gave the structure of Fig. 7, showing a smaller amount of pearlite while the normal rate gave a structure entirely free from pearlite as seen in Fig. 1.

That this steely structure is not due to improper annealing at the maximum temperature is shown by the following micrographs:

Fig. 8 shows the structure of a test bar which had been annealed at too low a temperature but had been cooled

*Charpy and Cornu, Compt. rend. 157,901.

slowly. This shows the dentrites of undecomposed cementite in a background of ferrite with a few specks of temper carbon. The steely structure due to rapid cooling is not present.

If the annealing is not entirely finished the structure of Fig. 9 is obtained showing specks of cementite with a large amount of temper carbon. In the section of commercial iron of Fig. 10 traces of cementite particles remain.

If the cooling is too rapid after improper annealing the structure is similar to that of Fig. 8 except that the background is pearlite and not ferrite.

It is evident that if a steely structure is the result of rapid cooling there must exist a critical range in which this undecomposed carbide breaks down into iron and carbon. If this remaining carbide breaks down in the critical range the largest part is decomposed at the maximum annealing temperature. All of the cementite does not decompose at this high temperature, but only decomposes at the lower temperatures of the critical range.

In order to comfirm these deductions and also to ascertain the critical range for the iron in question the following experiments were carried out. Sections of malleable iron which had been perfectly annealed were heated to varying temperatures for different lengths of time and then cooled in the air. In this way the temperature at which the temper carbon went into solution in the ferrite was ascertained by the amount of pearlite present.

Specimens heated to 775 degrees Cent. for two hours did not show any solution of the carbon and were malleable, showing no signs of pearlite. Upon heating to 800 degrees Cent. for five minutes no carbon was found to have gone in solution, but upon heating for two hours a small amount of carbon went into solution. Under the microscope the percentage appeared to be about 0.25. By heating at 850 degrees Cent. for five minutes the entire specimen consisted of pearlite and temper carbon and was brittle. By heating at 900 degrees Cent. the specimen was very brittle. These

experiments showed that below 775 degrees carbon was not soluble in the ferrite while at 850 degrees the amount was at least 0.90 per cent. The author regrets that analyses were not made to obtain the exact figures.

The experiments showed conclusively that it would be impossible to obtain a complete breakdown of the carbide at the annealing temperature since the carbon is soluble to a limited extent at this temperature. Also, the breakdown of this residual carbide is not complete except in the range of temperature below 775 degrees Cent. These results also show that malleable iron may be heated to 775 degrees Cent. without danger of forming a steely structure and consequent loss of malleability.

But if the breakdown is complete below 775 degrees Cent. what is the minimum temperature at which this decomposition may occur? The temperature, 700 degrees Cent., is the austenite breakdown temperature and was chosen arbitrarily since above this the iron carbide is in solution while below it occurs free. Chemical compounds are more easily decomposed when in solution and for this reason it was thought that this might apply to the cementite.

Samples of malleable iron were first heated to 900 degrees Cent. for five minutes to insure the solution of a certain proportion of temper carbon. The specimens were then cooled to temperatures varying from 650 to 800 degrees Cent. and kept at these temperatures for varying lengths of time. The results were in accord with the theory.

Specimens heated at 700 to 775 degrees Cent. for from 4 to 5 hours showed a structure like the original malleable, temper carbon and ferrite, showing a complete breakdown of the cementite. Specimens heated at 650 and 675 degrees Cent. did not show traces of a breakdown even when annealed for six hours. Annealing at 800 degrees showed a partial breakdown, as expected.

From this data the following conclusions were drawn:

1.—The critical range of cooling is between 700 and 775 degrees Cent.

2.—Below 700 degrees Cent. no decomposition of iron carbide occurs.

3.—All malleable iron must be slowly cooled to 700 degrees Cent. to insure a complete breakdown of the iron carbide.

4.—Increasing the percentage of silicon will increase the upper limit while increasing the manganese will decrease it.

In addition to the experiments upon malleable iron similar experiments were run upon gray cast iron. Similar results were obtained though the upper temperature limits were higher, probably due to a higher silicon content.

By heating at 900 degrees Cent., the structure consisted entirely of uniform pearlite. By heating at 850 degrees for several hours practically no change took place, the structure being pearlite and graphite with areas of ferrite. By heating at 800 degrees for several hours the pearlite in the original casting was broken down completely. The same results were obtained at 750 degrees and 700 degrees but no change occurred upon heating below 700 degrees.

It is noteworthy to remark that the areas of ferrite formed upon heating were much smaller than the original ferrite areas. It is probable that the refining of the grain upon reheating the cast iron through the critical range would cause a fine grained ferrite to form.

White Iron Annealed

In testing the conclusions reached in the above experiments, sections of white iron were annealed as follows:

1.—Annealed at 875 degrees Cent. for 50 hours, cooled quickly to 750 degrees, kept at this temperature for 10 hours and quickly cooled. An excellent malleable structure resulted.

2.—Annealed at 775 degrees for 90 hours and quickly cooled. An excellent malleable structure was obtained but traces of cementite remained showing that this time was too short at this temperature.

3.—Annealed at 875 degrees for 50 hours. cooled quickly to 650 degrees, kept at this temperature for 20 hours and quickly cooled. A steely, brittle structure resulted.

From the result of these annealing experiments the critical range is shown to be between 700 and 775 degrees Cent. and that it is necessary to give sufficient time for the completion of the carbide breakdown in this range. In all of the experi-

ments it was found that the best results were obtained if the cooling was slow through this temperature range.

Reactions in the Annealing Process

As a result of the investigation some progress was made in the determination of the reactions resulting in the breakdown of the iron carbide to form ferrite and temper carbon. It has been generally supposed that the iron carbide broke down directly at the annealing temperature. In this research the results seem to show that the carbide does not break down directly, but decomposes only when in solution in ferrite as austenite. It must be understood that the author does not wish to imply that iron carbide will not decompose directly, but that in this case the iron carbide in solution will decompose more readily than that in the free state.

The following data are significant in determining the reactions resulting in the malleable iron structure:

1.—When malleable is heated for too short a time or too low a temperature and slowly cooled the structure consists of ferrite, cementite and temper carbon, Fig. 8.

2.—Correct annealing results in a structure which consists entirely of ferrite and temper carbon, Fig. 1.

3.—Cooling too rapidly after correct annealing at the maximum temperature results in a structure of temper carbon surrounded by ferrite, in turn enclosed by pearlite, Fig. 6.

4.—By annealing at too low a temperature and cooling rapidly the specimen consists of areas of excess cementite surrounded by pearlite and small particles of temper carbon surrounded by ferrite.

5.—At 800 degrees Cent. the temper carbon begins to go into solution.

6.—Above 700 degrees the carbide breaks down completely, but no decomposition occurs below this temperature.

The white iron consists of pearlite and cementite. Since the pearlite consists of plates of ferrite and cementite the entire white iron has two constituents, ferrite and cementite.

When the hard casting is heated to be annealed the constituents of the pearlite go into solution as austenite at 700

degrees Cent. At the annealing temperature a portion of the excess cementite also goes into solution. When the breakdown occurs does the excess cementite or does that in solution as austenite decompose first?

If the excess broke down first the reaction should show some free graphite scattered in areas of cementite. Instead of a uniform breakdown and the scattered formation of temper carbon these cementite areas grow smaller as though they were being gradually dissolved while the temper carbon forms in large patches. There is no evidence of a direct decomposition of the excess cementite.

When the cementite in the austenite decomposes it deposits the temper carbon while the ferrite is liberated. This ferrite dissolves more of the excess cementite. The nucleus of temper carbon hastens the breakdown of the carbide.

In specimens which have been imperfectly annealed and show areas of excess cementite, Fig. 8, the cementite adjoining temper carbon areas is much smaller than that farthest away. The area directly about the temper carbon is usually free from cementite. This would result if the cementite dissolved as austenite is decomposed. Since the ferrite is liberated at the temper carbon, the concentration of this constituent would be greater there and the excess cementite in the immediate vicinity would be more quickly dissolved than that farther away.

The decomposition of the iron carbide in the austenite is not complete at the annealing temperature, 850 to 875 degrees Cent., but is complete at about 775 degrees Cent. The lower the temperature the less stable the cementite, depending upon the silicon and manganese present. But below 700 degrees this rule does not hold since the iron carbide is again stable owing to the dissociation of the austenite into its constituents as pearlite. The carbide is not in solution below 700 degrees and is again stable, as was shown in the experiments.

The author wishes to express his appreciation of the valuable assistance given by the Northern Chemical Engineering Laboratories in the carrying out of the research and in the preparation of this paper.

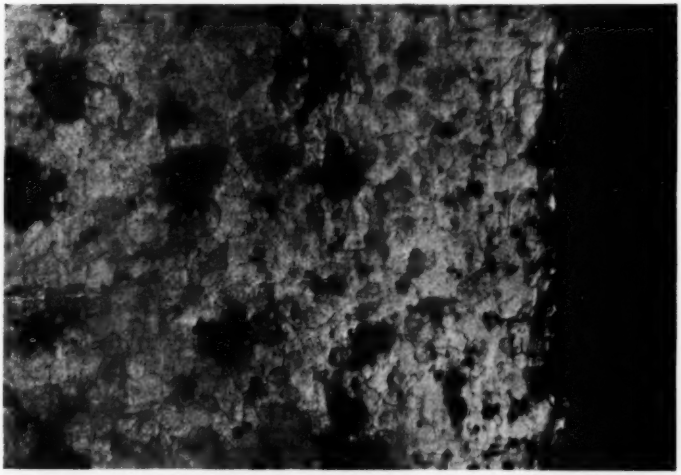

FIG. 1—MICROGRAPH OF MALLEABLE SPECIMEN SHOWING CARBONLESS RIM
(Magnification, 100 diameters)

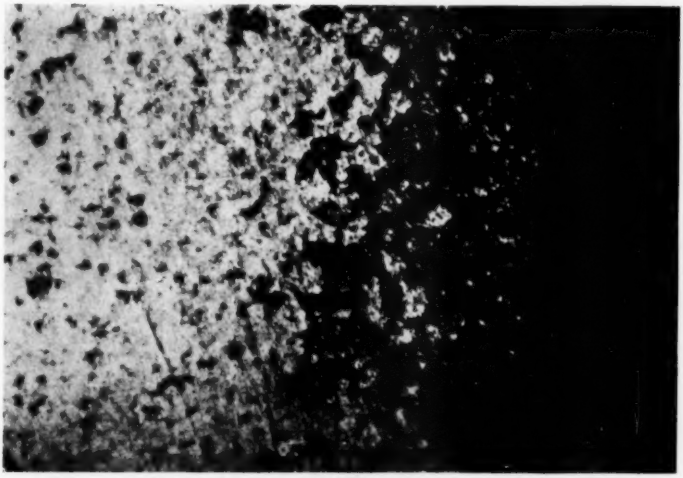

FIG. 2—MICROGRAPH OF MALLEABLE SPECIMEN SHOWING STEELY RIM
(Magnification 50 diameters)

FIG. 3—MICROGRAPH OF MALLEABLE SPECIMEN SHOWING HARD RIM
(Magnification, 75 diameters)

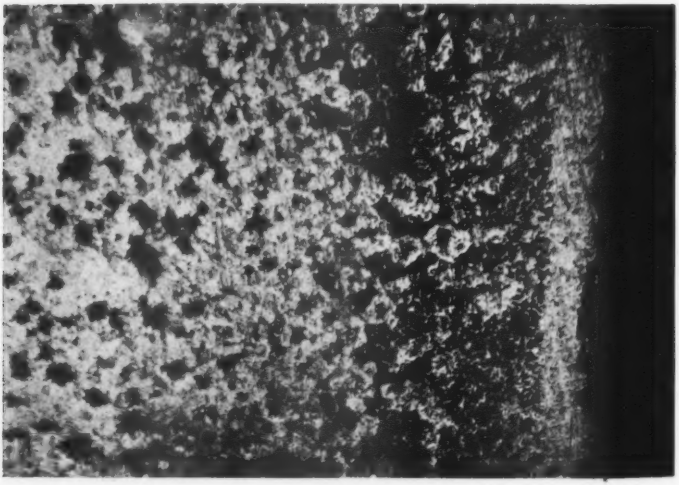

FIG. 4—MICROGRAPH OF MALLEABLE STRUCTURE MOST FREQUENTLY OBTAINED IN COMMERCIAL WORK
(Magnification, 30 diameters)

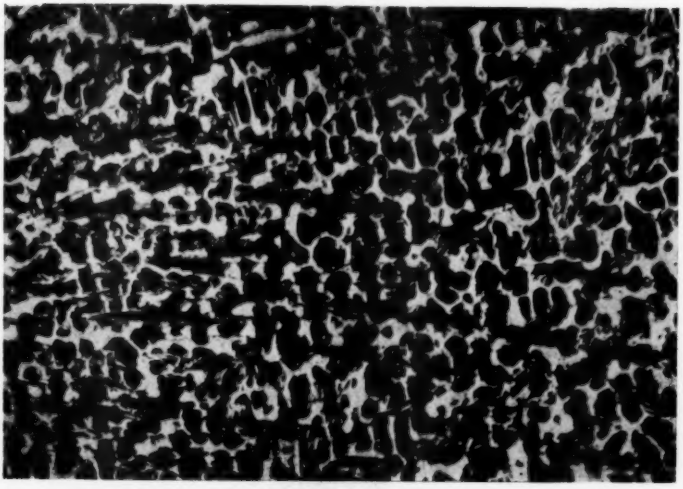

FIG. 5—MICROGRAPH OF WHITE CASTING SHOWING CARBON IN COMBINED STATE
(Magnification, 100 diameters)

FIG. 6—SPECKS OF TEMPER CARBON SURROUNDED BY PURE FERRITE IN A BACKGROUND OF PEARLITE
(Magnification, 100 diameters)

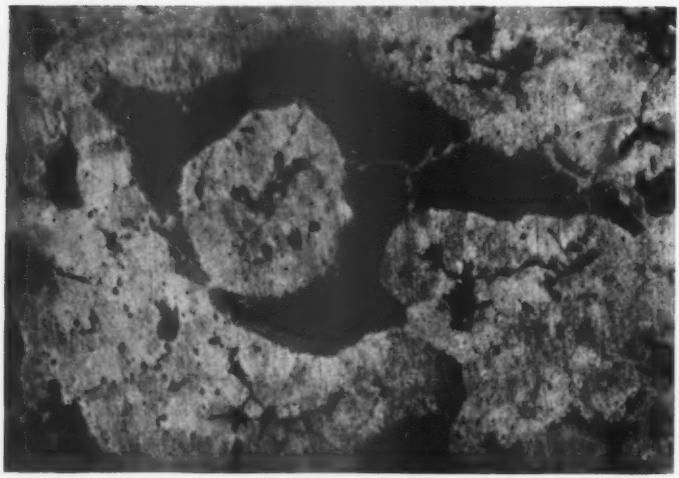

FIG. 7—STRUCTURE RESULTING FROM A LOWER RATE OF COOLING THAN FIG. 6
(Magnification, 100 diameters)

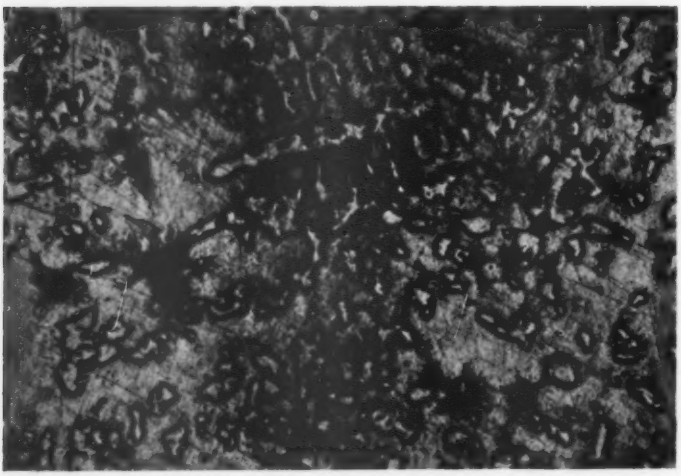

FIG. 8—STRUCTURE RESULTING FROM ANNEALING AT TOO LOW A TEMPERATURE, BUT SLOWLY COOLED
(Magnification, 100 diameters)

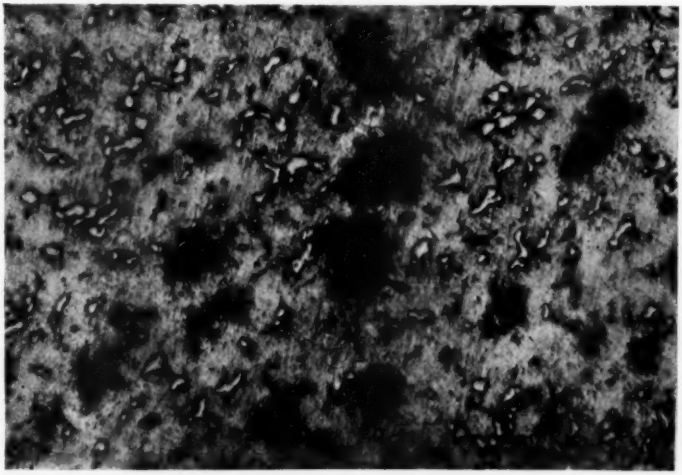

FIG. 9—STRUCTURE SHOWING INCOMPLETE ANNEALING
(Magnification, 100 diameters)

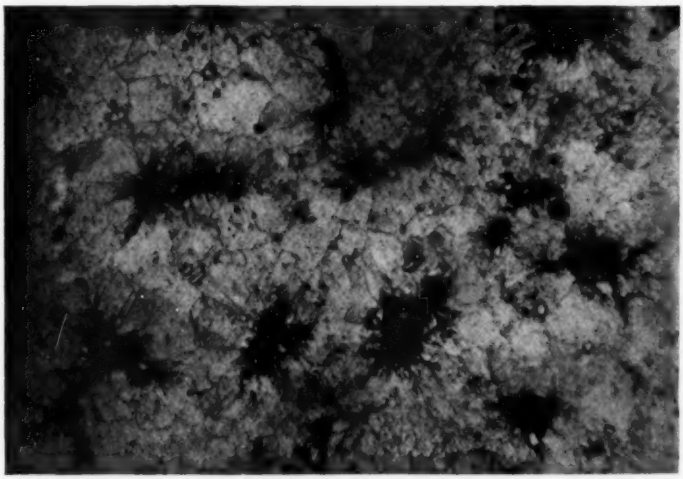

FIG. 10—SECTION OF COMMERCIAL IRON SHOWING TRACES OF CEMENTITE PARTICLES
(Magnification, 100 diameters)

Discussion of Malleable Practice

THE CHAIRMAN, MR. ALFRED E. HOWELL:—Mr. Pero, you mention that malleable iron is used now in stoves and ranges. I would like to ask you what is the advantage or supposed advantage of using malleable iron in such articles as stoves and ranges?

MR. J. P. PERO:—They are less liable to break, that is the first consideration. I believe when stove makers first went into the manufacture of malleable iron ranges, the talking point was that such a range was indestructible and one of the firms that first went into the work sold not through jobbing houses or stores, but by wagons around the country. One of their selling points was to dump a range off the wagon and show that it was intact. The effect of the heat of the stove on malleable iron is less destructive than it is on gray iron. In gray iron ranges you will find that the tops crack and the covers get out of shape, but not in the malleable iron, that was another consideration.

THE CHAIRMAN:—I would like to ask if that advantage extends to the fire box of the range.

MR. J. P. PERO:—No, for the fire box they usually use brick, or in some cases, heavy cast iron.

THE CHAIRMAN:—Would the malleable iron stand the heat without warping? Would it hold its position as well as the gray iron?

MR. J. P. PERO:—Yes. You must remember that malleable iron is annealed at about 900 degrees Cent. or 1,500 degrees Fahr., and until you get up to that heat in your stove or range, you are not going to affect the malleable iron. There will be some little expansion but not as much as in the case of gray iron under the same conditions. After a malleable iron fire

box is heated up to cherry red, if cooled too quickly, the malleability of the iron is destroyed. With the slow cooling that it gets under ordinary firing, this would not occur. In ranges, malleable iron is used principally in the sides, tops, doors and door frames without any regard to the fire box, although they do use malleable iron for waterbacks and waterfronts in these ranges, which is pretty good evidence that it stands up well.

MR. ENRIQUE TOUCEDA:—I hardly know what remarks to make on Mr. Hemenway's paper on calculating mixtures. It looked to me like making a simple matter complicated. I don't quite see the idea or the necessity of all those charts and figures. The method would never appeal to me. There were some remarks Mr. Hemenway made in regard to fluidity, but he neglected to mention the constituent which has the greatest effect on fluidity, which is carbon. Also I have seen many good castings with 0.13 per cent sulphur and many good castings with 1.25 per cent silicon, the ranges being very wide, but it is necessary to have the ratios all right; if you get the ratios all right, then you have a wide limit for the different impurities. Then Mr. Hemenway spoke in connection with the heat value of silicon in the air furnace. You can obtain great value from silicon in the Bessemer converter, where you turn out ten tons of steel inside of 15 minutes or less and where the fuel is really the silicon, but I don't think it cuts any ice in the malleable process, because you are oxidizing only about 0.4 per cent of silicon in some three hours, and it is not solely the B. T. U.'s in the fuel that count, but how quickly you use them that gives you their value. You are radiating heat from the air furnace about 50 times as fast as you are getting heat from the available silicon.

MR. J. P. PERO:—In connection with that paper, I would like to ask a little information. As nearly as I could follow it, Mr. Hemenway treated entirely of the silicon in the mixture. Of course we know that the carbon runs about the same in the different pig irons, but silicon is a very varying quantity; so also is the sulphur and the manganese. The phosphorus we

are not worrying much about, as that element remains unchanged in the furnace, but the manganese and the sulphur in malleable iron are just as essential, that is the proper relation one to the other of them, as the silicon. I personally would not dare to make a mixture without considering both those elements very carefully; in fact our mixtures are made with the consideration of the silicon, and the sulphur first, and when we have determined our sulphur in the mixture, we determine our manganese afterward. Those were points that were not covered and I would like to know what provision is made for covering them?

MR. HARROLD HEMENWAY:—According to my practice, the manganese is taken care of in the different grades of pig iron used, but in order to obtain a certain silicon content, you calculate the heat. Mr. Touceda said it would only take five minutes—to calculate a heat by his method, with my method you can do it in a minute, saving four minutes. With a proper heat card, the heat can be calculated without stopping to figure the silicon contents and a heat of a certain size with so many pounds of silicon in it can be determined by the grade.

MR. M. LA RUE:—I would like to ask Mr. Pero what tests he made in regard to malleable iron being poured at a higher temperature than gray iron? It is true that the melting point of iron depends on the percentage of combined carbon and the higher the combined carbon, the lower the melting point; and isn't it true that malleable iron is really poured at a lower temperature than gray iron? I believe that Dr. Moldenke mentioned the fact in one of his books, that he had made some tests on that point and that malleable iron is poured at a lower temperature than gray iron.

MR. J. P. PERO:—I think my statement is right. It is only recently that we have had any knowledge of temperatures in the melting of iron, that is, in comparatively recent years. When I was in the gray iron business, which I was some years ago, we had no means then of knowing the temperature of our gray iron. We judged our iron by the eye; on a dark day the

iron appeared to be hotter than on a bright day, you all know that. But now we have means of ascertaining, and probably most of us in the malleable iron business are using pyrometers on our furnaces. I don't really know what the pyrometers are actually showing in gray iron practice. I know what the engineering books say, and they vary quite a little. From what we get from engineering books, we could assume either that the malleable iron is poured hotter, or that the gray iron is poured hotter, and be perfectly right in either assumption. We do know, however, that malleable iron is so much less fluid than the gray iron that we melt it mighty hot, hotter than we have occasion to use gray iron, and I believe we are melting and pouring malleable iron at a higher temperature than gray iron on the same class of work.

MR. M. LA RUE:—I wanted to know if he had investigated that point himself and knew positively that what he said was true? My impression is the other way around.

THE CHAIRMAN:—Can you tell us about that, Mr. Touceda? He wants to know whether malleable or gray iron is poured at a hotter temperature?

MR. ENRIQUE TOUCEDA:—The rule is this; the lower the percentage of impurities, the higher the melting temperature in any metal. Steel comes next to wrought iron, malleable iron next to steel and gray iron next. Malleable iron I should judge would melt around 2,350 degrees but of course you couldn't pour it at that temperature; steel would melt around 2,600 and wrought iron around 2,800.

MR. J. P. PERO:—I will say, as a matter of information that we use a radiation pyrometer on our furnace and it shows the highest temperature in the heat to be from 2,300 to 2,400 degrees Fahr.

MR. S. G. FLAGG III:—With regard to this matter in question, about a year or so ago, with the aid of our chemist, I took some tests of the temperature of gray iron and malleable iron coming down the spout in the cupola, and while I cannot

give you the exact figures the gray iron appeared, with a radiation pyrometer, to be about 300 degrees hotter, coming down the spout, than the malleable iron, but I cannot tell you what the temperatures were.

MR. THRUSHER:—I would just say that in my personal experience, limited to the use of the radiation pyrometer that Mr. Pero has spoken of, some temperatures I took a couple of years ago at Mr. Flagg's plant indicated that castings of about the same section were poured near the same temperature; that is malleable was running from 2,400 to 2,600 degrees and light gray iron the same. The same sections were poured within the same range of temperatures very closely. The radiation pyrometer is more or less open to question, in that the radiation is different from different compositions of metal, and I am not positive that it is very reliable, on that account. It seems that at times, while the metal was cooling, an oxide formed over the surface which gave a higher indication than the metal itself did, so that you can see the difficulties in determining temperatures with a radiation pyrometer.

MR. T. BENNETT:—I would like to hear the question of the safety limit in manganese for the proper annealing of castings of different grades discussed here, also its relation to sulphur. I think this is a question that concerns every malleable iron manufacturer and every iron producer.

MR. ENRIQUE TOUCEDA:—Why, it is absolutely essential to have certain ratios in regard to your sulphur and manganese; there is no question about that. I don't know that I feel just at liberty to state exactly what the relations ought to be.

MR. T. BENNETT:—Do you feel like stating what the outside limits of manganese in relation to sulphur should be?

MR. ENRIQUE TOUCEDA:—Why, yes; I think that you are very safe if you don't run your manganese under 0.2 per cent and that you will be up against it if you run it over 0.35 per cent.

MR. T. BENNETT:—In what grade of malleable?

MR. ENRIQUE TOUCEDA:—In any grade of malleable, but whether you run it one or the other depends upon your sulphur content.

MR. M. LA RUE:—One time in our shop the foundry foreman made a mistake and instead of adding silica, he added manganese and we had 0.60 per cent in the castings. The castings did not anneal satisfactorily; they were brittle compared with the regular malleable. Our heats have run as low as 0.23 per cent in manganese and these have annealed satisfactorily up to as high as 0.38 per cent, with a sulphur content always under 0.05 per cent.

MR. WILLIAMS:—I would like to ask if there are any satisfactory pyrometers for malleable annealing furnaces?

MR. J. P. PERO:—Why, there are different ones. We are using a radiation pyrometer, but I don't think it is absolutely positive. It is a matter of getting the proper focus to get the correct radiation, and I think it is all right for practical work. It would not be a laboratory pyrometer, in my estimation. In our melting furnace we don't get the heat of the iron, we get the heat of the gases and we do that in this manner. We have a hole cut in the plate of the furnace about three inches in diameter, directly through into the melting chamber just behind the front bridge. We flare that hole by using one of the brick that we use for a tap hole. We get the pyrometer on the outside at the proper focus and then we pull it out a little bit and it drops, and we shove it in a little bit and it goes up, and we get our focus in that way. It would not be a laboratory pyrometer, but we get the temperature very close in practice in that way.

THE CHAIRMAN:—I would like to ask Mr. Touceda if in his opinion the increase in the use of malleable castings in automobiles is not very considerable. Do you find that is the case, Mr. Touceda?

MR. ENRIQUE TOUCEDA:—I think that the use of malleable castings in the automobile industry is increasing. I happen to

be a member of the American Society of Automobile Engineers and I know that some of the cycle car builders are now making their axles of malleable iron. I think malleable iron is destined to have a great future.

MR. H. B. SWAN:—I believe the steel forging is somewhat replacing the malleable casting, because a motor car manufacturer attempts to standardize his parts as much as possible and after the die for the forging is made, I believe it is better to use the forging than the casting.

The Electric Furnace in the Foundry

By W. L. Morrison, Welland, Ont.

The electric furnace for the production of steel castings is a subject of much discussion among the foundrymen of today. It will no doubt take some time and much patience on the part of those operating them, before reliable and tangible data on their operation and upkeep may be available. All new apparatus must go through the experimental stage; and as is the case with every such apparatus, or article for the market, there are several new electric furnaces offered the public each year which only add to the confusion of the foundryman investigating the advisability of installing such a unit. It is not intended here to take up any particular make of furnace, or discuss relative merits, but the writer will try to point out some of the difficulties met with in practice, and the possible future of the electric furnace.

The electric steel furnace coming to us from Europe, having originated there, received considerable development before it was introduced into this country. I do not mean by this that the electric furnace had reached its final stage of development, as it is far from that today. But the fact that the electric furnace was developed in Europe brought European practice, to a greater or less extent, with the furnace to the States. In certain practice and for some grades of steel European methods are excellent, and can be but little improved upon when the quality of steel is paramount. This covers for the main part crucible tool steel. There are so many items entering into relative costs between the crucible and the electric furnace method, that the electric refining of steel may be carried to a nicety and still produce steel lower in cost, than can be produced by the crucible method. Although this is the case, the crucible steel manufacturers of today are proceeding very cautiously, and it will take several years for them as a body to put faith in the electric furnace.

The electric furnace in the foundry is a more difficult proposition, on account of the keen competition in the steel casting trade. In Europe, raw materials, low wage scale, and low power rates, lend themselves very readily to the production of the higher grade of steel castings in the electric furnace. I understand the electric furnace abroad is in competition with tonnage furnaces.

Price of Electric Steel Castings

In some localities in America electric steel castings are selling at a higher price than is asked for crucible steel. The customer as a rule prefers electric steel, but is unwilling to pay a higher price. For this reason those who install an electric furnace for the purpose of producing a higher grade of steel and who expect an increased selling price, are apt to meet with difficulty in keeping the furnace operating at capacity. The electric furnace is installed at present with the idea of replacing the crucible process, and making a better quality of steel. In many localities, and for numerous purposes the so-called Tropenas converter steel is replacing to a large extent crucible steel. Now the question is can the electric furnace compete with the converter process. If the price of pig iron does not lower, the electric furnace is going to come into competition with the converter, but of course this will all take time.

I believe the future of the electric furnace in the foundry is only insured by a very close analysis of its operation, and the adaptation of its operation so as to cheapen the product and obtain a greater output. This can be done either with an acid furnace or basic furnace. For low carbon steels (i. e. less than 0.20 per cent) low phosphorus and low sulphur are not as essential as with the higher carbon steels. Under good operating conditions steel can be produced in the ladle from a two-ton electric furnace at from $20.00 to $30.00 per ton where no refining is necessary. This covers low carbon steels (0.08 to 0.20 per cent). Taking three heats per day, with ordinary care the average cost of steel in the ladle should not exceed $30.00, even with power at 1.5c per kilowatt-hour.

The demand at present for an alloy, or plain steel containing more than 0.40 per cent carbon is very limited, for the heat treatment of steel castings on a large scale is also in its infancy so to speak. This will be a branch of the steel casting industry in which the electric furnace will reign supreme, for in quality and soundness of casting it will supersede the crucible method. Steel can be melted and refined in the electric furnace for from $27.00 to $35.00 per ton in the ladle, depending on the power cost, cost of materials and the care of the melter.

The electric furnace today is somewhat overrated by claims that it is especially adapted to all foundry use; that its operation is very simple and easily mastered; and that the hottest kind of metal is obtained, so that low carbon steels can be poured in the thinnest sections. All these statements are more or less true, but should be investigated by the foundryman, so as to avoid disappointment after installation.

There are some installations of electric furnaces which have been made during the past two years, which did not come up to the expectations of the foundryman, and were either abandoned, or operated in a half-hearted way. An electric furnace installed with the idea that one heat a day will pay its way is disastrous to the foundry. The electric furnace while adapted to foundry work under certain conditions, should not be considered as an ordinary piece of apparatus. It is very delicate, or at least certain parts are, as one finds out in practice. A careless melter can add $5.00 to $15.00 to the cost of a heat from electrode breakage, by neglecting to raise his electrodes during the removal of slag, or when charging the furnace.

In the charging of the furnace a certain amount of care must be exercised to insure prompt electrical contact and smooth working of the electrodes. I think the electric furnace involves more good common sense and observation, than any of the well known methods of producing steel. It is very easy to lose an hour or even three hours by poor electrical contact at the offset, due to either poor charging, or poor selection of scrap. Those who have had practical experience with the fur-

nace know how aggravating a poor electrical contact is; on the other hand a short circuit the moment the arc is made and subsequent surges of current are readily overcome by placing a little slag around the electrodes.

The operation of the furnace and the reactions taking place appear so simple that the ordinary spectator is apt to be misled. Without doubt the electric furnace is an ideal medium for carrying on the reactions necessary for the refining of steel. It is almost like carrying out a reaction in the chemical laboratory.

While very low carbon steel can be made and poured, much difficulty will be encountered as you all know if one attempts to pour any considerable amount of steel into small work from one ladle. If it is desired to make 0.10 carbon steel small heats can be made in the electric furnace for very little increase in cost, although the ladle cost of course would run quite high. The making of this low carbon steel and getting it hot enough to pour light work, is done at the expense of the arch of the furnace, which would necessarily need repairs oftener. Forced operations are also hard on the arch. Sharp corners, or angles should be avoided, as they cut very quickly.

A plant warranting the installation of two furnaces, and operating one basic and the other acid bottom, would offer an ideal condition, where cheap, low grade scrap is available, melting and refining on the basic bottom, then using the scrap from the basic furnace in the acid furnace.

The increased strength of electric steels of similar composition to those made by other processes has not been satisfactorily explained as yet. Even low grade steels made in the electric furnace similar in composition to the converter steels possess superior properties to converter steel. The fact that steel made in the electric furnace is in a reducing atmosphere seems a very plausible reason for the difference in properties. It has been demonstrated frequently that certain alloy steels made in the electric furnace of the arc type, could not be reproduced in the crucible furnace.

In both cases we have a reducing atmosphere. A suggestion as to this difference is that the intense local heating by

the "submerged arc" produces certain carbides or combinations of carbides and alloys of the other ingredients in the steel which are not fully understood today. The fact that electric steel has less of segregation tends to show a greater uniformity and stability of the alloys of iron when produced in the arc furnace. This fact also helps to explain the superior properties of electric steel castings.

Efficiency

The efficiency of the electric furnace depends upon three important factors: The electrical design, metallurgical design, and the operation.

The electrical design is perhaps the most important, and is the hardest point for the foundryman to decide upon and understand; for, so to speak it is the "bone of contention," among those interested in the electric furnace from a sales point of view. We hear much talk about kilowatt consumption per ton of steel in the ladle, and because one furnace shows a lower kilowatt consumption than another, it would lead you to think it the more economical to operate, but in reality the power cost might be greater despite the lower kilowatt consumption. The reason for this is that the power factor enters into the power question, and is very important in connection with electric furnaces. A load with a low power factor is very undesirable at the central station, and most electric distributing companies have a penalty for low power factors. If the electric company would allow a low power factor, it would be to the advantage of the consumer operating an electric furnace, to use a furnace with a low power factor as the output would no doubt be greater per kilowatt-hour. However, should the power company submit to the low power factor without a penalty, I feel it would only be a matter of time till the power factor would have to be raised by further installation of electrical apparatus.

There are furnaces operating today with a power factor of from 90 to 97 per cent, while other furnaces on the market have a power factor as low as 40 to 60 per cent, and in order to raise their electrical efficiency they would need special

apparatus, or should be operated by special alternators having a low frequency.

The power consumption of furnaces should be expressed in kilovolt-amperes, so the figures given in technical literature would be less misleading. Take for example the submerged arc type of furnace, with either the three phase or the single phase, operating under similar conditions. Generally speaking the higher the power factor the less will be the kilovolt-ampere consumption. It is understood when speaking of current, or power consumption, that the transformer losses are included. The following is a typical illustration of the above. A certain furnace claims a current consumption of 586 kilowatt hours per ton of steel in the ladle, melting cold scrap, the power factor being 50 to 60 per cent. Another furnace claims 800 kilowatt hours per ton of steel in the ladle under similar conditions, but with a power factor 90 to 95 per cent.

(1) $586 \div .60 = 976$ Kva. hrs.
(2) $800 \div .90 = 889$ Kva. hrs.

The former case appears the more economical of current consumption when considering the kilowatt, but figuring the kilovolt-ampere consumption, the latter is about 10 per cent more efficient. All furnaces working with a heavy inductive load must necessarily have a larger kilovolt-ampere consumption, other things being equal. To this class belong all induction furnaces, and single phase furnaces operated on a three phase circuit. The three phase furnace might be included in this class during certain periods of its operation, if not properly handled (that is running with an unbalanced load). The furnaces having less inductive load and possibly lower kilovolt-ampere consumption, are those operated on three phase and single phase systems. The ideal current for electric furnace work is direct current, but this is objectional on account of higher cost of installation of large units, cost of maintenance, and losses of transformation from alternating to direct current. Summing up the above, the furnace and equipment should be such as to maintain as high a power factor as possible in keeping with efficiency.

The metallurgical design of the furnace should be such as to conserve the heat generated by the electric arc, and facilitate the operation and repairs of the furnace. The design of the furnace for the conservation of the heat, etc., depends to some extent upon the melting stock available, and the quality of the steel to be made, that is whether an acid bottom, or a basic bottom be employed. The acid bottom is limited in its scope of operation, for while it produces a very good steel, the refining cannot be carried as far as on a basic bottom. The basic bottom is the one more commonly used and will be considered in this paper.

The methods of lining the furnaces are all similar, and an experienced melter exercising ordinary care can put in a good bottom. The basic furnace must have sufficient openings to facilitate the charging, working of the heat, and carrying on the necessary repairs at the end of the heat. Some furnaces have very scant openings, designed for the conservation of the heat, but the operation is materially retarded, and the designer unconsciously lowers the efficiency. Nearly everyone connected with electric furnaces realizes the advantage of continuous operation, especially if the power is purchased under contract. The repair overhead per ton of metal is lessened and the thermal efficiency greatly increased.

In regard to choice of material for electrodes for the small furnace, this is somewhat an open question at the present time. To meet the need of large electrodes the amorphous carbon electrodes are being greatly improved, and are replacing the graphite electrodes in the larger furnaces. The recent developments in the manufacture of amorphous electrodes, enables the splicing of two sections, and spawling is greatly decreased. The graphite electrode is still extensively used in this country, and if it were not for the great cost (about three times that of amorphous carbon) it would be used much more extensively on account of superior advantages it possesses. Its chief advantages are, the ease of machining and strength of the joint between two sections, the high electric conductivity, uniformity of composition, and slower oxidation under oxidizing conditions. Generally speaking on small electric steel fur-

naces, three tons capacity and less, operating intermittently the cost of electrodes per ton of steel in the ladle is a little in favor of the graphite, however on the larger furnaces I understand the large amorphous electrodes are more satisfactory and cheaper per ton of steel made. There is little practical data on the relative merits of the two electrodes, except regarding their thermal and electrical efficiencies. As regards the relative advantages in steel making, from a metallurgical point, we must await developments. However, it is well known that the amorphous carbon gives a larger area of cross-section for a certain current density.

The larger amorphous carbon electrode gives better distribution of heat to the steel bath, and offers some protection to the arch of the furnace. The grouping of graphite electrodes has been largely replaced by the single amorphous carbon electrode. At present the size of graphite electrodes is limited to 8 inches diameter, on account of difficulties encountered in graphitizing those of larger diameter. The only limit to size of the amorphous carbon electrode is that which will carry safely when the furnace is tilted or during operation.

Operation of the Furnace

Producing good steel economically depends largely upon the melter. While a steel melter can be trained for the electric furnace in a shorter time than for the open-hearth, this fact is too often abused, with the loss of heats and cold steel in the ladle. Then too, often the furnace is blamed for the results when the melter is really to blame. Only a short time ago when the manager of a large crucible steel plant investigated the operations of a certain electric furnace, he saw several cold heats of steel poured, and decided the furnace was not adapted to his class of work.

When it is desired to produce a large tonnage of soft steel, that is 0.12 to 0.15 per cent carbon, excellent results may be obtained by the use of one slag, lowering the carbon to near the desired point, and recarburizing, without attempting to whiten the slag. With the proper additions of alloys the steel

will pour very fluid and sound castings will result. However the iron oxide must be used very sparingly for decarburizing, 50 pounds to the ton of scrap usually being sufficient. Steel made this way is not quite so high grade as that made in the usual way, but it can be produced 10 to 25 per cent cheaper. The basic bottom can be used to compete with the acid lined electric furnace, by limiting the refining.

In the making of low carbon steel I find that a fairly fluid slag near the finish of the heat, gives hotter steel, a better cast, and less tendency to skull in the ladle. The demand among the jobbers for a low carbon steel casting seems to be increasing, being more of a fad than an actual necessity.

Attempting to make steel castings less than 0.10 per cent carbon, except for special purposes, I consider detrimental to the steel casting trade and especially to the future of the electric furnace. The cost of producing this steel is increased at the furnace, in the foundry, and perhaps one can add, in the cleaning department. The higher temperature required to maintain a fluid metal, necessitates an added repair cost, and heavier overhead on the furnace. In the foundry larger shrink heads are required, and there is greater danger from misrun castings lowering the efficiency in the foundry. The gates and risers on the castings are harder to remove where the carbon is low. This is very noticeable even with the oxy-acetylene torch. For the great bulk of small work some foundries are considering raising the carbon content and paying more attention to the annealing. Without doubt there would be economy in the casting and the cleaning, and perhaps the customer would get a steel better adapted to his purpose. There are some foundries investigating from these standpoints comparative costs of productions. On account of the expense of such investigations, manufactors are quite reluctant about giving out figures.

Considerable data is available in current technical literature both as to cost of installation and cost of operation of electric furnaces. Many good papers have also been written on the methods of operating the electric furnace. I might

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add that the costs of operating electric furnaces usually given out to the public are those for ideal conditions. While the manufacturer considering the installation of such a furnace may attain such efficiency, he would be less liable to disappointment if he were to add from 10 to 25 per cent to the figures given as his possible cost of production. Cost of steel in the ladle usually varies very little from day to day as produced from the electric furnace, but cost of the saleable steel castings is the item that is most important. There is no fixed rule or standard for the foundryman to follow in reaching a decision as to the advisability of an electric furnace installation. The possible increased demand for electric steel castings would no doubt hasten his decision.

When steel castings have the same attention and care in their manufacture that is given our tool steel, we can hope for greater progress in the electric steel casting industry.

Discussion of the Electric Furnace in the Foundry

MR. F. T. SNYDER:—I am sure that the practical foundrymen who attended this convention, listened to Mr. Morrison's paper on electric furnaces in the foundry, with a great deal of interest. It is rapidly becoming clear to those of us who are in intimate contact with the electric furnace in the steel field, that this field of application is rapidly broadening, and that it does not require very much of a spirit of prophecy to understand that not only the small foundry, but all, including the largest types of open-hearth steel furnaces, are destined to gradually change to an electric basis, just as the present open-hearth practice has grown out of the previous Bessemer practice.

It will perhaps be of some value to add some data to Mr. Morrison's paper which has accumulated from experience not available to him. It is interesting to note that Mr. Morrison speaks of the electric furnaces in this country as having been brought from Europe. This was a relatively true statement a few years ago, but recently there has been developed in the United States furnaces which were designed by American engineers, and developed in American shop practice, and which for this reason have proved more suitable for American conditions than the earlier furnaces which came from Europe.

I would especially like to call attention to Mr. Morrison's statement, that in a 2-ton electric furnace, steel can be made from $20 to $30 per ton. We have a definite case in our own practice, where the steel in the ladle, from a furnace of about this size, is being made at a total cost, including all overhead charges, of something under $17 per ton. It might be well to amplify Mr. Morrison's remarks by stating that there have been successful installations made in this country from American-designed furnaces, in which, on a basis of one heat per day, the furnace has saved the entire cost of installation inside of the first year.

Speaking of the power consumption of electric furnaces, it would seem as though Mr. Morrison had rather added to

the confusion than simplifying matters, by introducing the new unit—the kilovolt-ampere-hour. In actual electric power plant business, there is no such unit in use, and quite properly, its use does not mean anything commercially. All electric power bills are based on the kilowatt hour, and charge is made at a definite rate per kilowatt. The wattmeter, which is used to measure the power, does not measure kilovolt ampere hours, but measures kilowatt hours, and, therefore, the bill is based on kilowatt hours and not on kilovolt ampere hours. It is a fact which has been well demonstrated, in commercial practice, that the kilowatt hour consumption which has to be paid for for an electric furnace, is less for a low power factor than it is for a high power factor. In general, in this country, in small foundry electric steel furnaces, the high power factor furnace consumes from 900 to 1,000 kilowatt hours per ton of steel, while the low power factor furnace consumes from 600 to 700 under the same conditions. At 1 cent per kilowatt hour, this makes a difference of $2 per ton of steel saving to the foundrymen by using a low power factor furnace rather than a high power factor furnace.

There is another aspect of the matter, however, which is more important, and that is the power which is saved can be used to melt more steel in the same furnace. In other words, a low power factor furnace will melt from 25 to 35 per cent more steel per day than a high power factor furnace of the same size.

The question of high power factor is one of those cases which come from taking a narrow view of the matter under consideration. The electric power people are interested in having a high power factor, as it enables them to sell more current from the same equipment. When, however, we also take into consideration the foundrymen's point of view, we find that the amount saved to the power company by using a high power factor furnace is lost several times over to the foundrymen. The better economic plan is to consider the joint interests of the foundrymen and the power company, and to install low power factor equipment which will enable the greatest amount of joint profit to be made for the foundrymen

and for the power company. This economic procedure leaves the largest amount of profit to be divided between the power company and the foundry.

There is a further aspect in the matter, in that by using a low power factor, special forms of furnace regulation can be used, which very greatly simplify the construction of the furnace. This simplification of furnace equipment means reliability in the ordinary foundry which has to operate with the usual American labor. This matter of the reliability, which comes from simplicity of construction, is the essential difference between European types of electric steel furnaces, and the more modern American types. In Europe technically trained engineers are numerous, and low priced. In this country competitive conditions are such that the average foundry cannot afford to employ a high grade engineer to keep the auxiliary apparatus of electric furnace in operation. By utilizing low power factor furnaces the regulation of the furnace can be made a matter of the inherent furnace design, and all auxiliary regulating apparatus of every kind can be eliminated.

Another important aspect of the low power factor is that it permits the use of a flame arc in place of the spot arc. By using such a flame arc, which is very large and gives a flame something like an open-hearth furnace, the intensity of the electric heating is greatly diminished, and this shows up in a phenomenally low refractory cost, which is being obtained with the flame arc furnace. Refractory costs, for comparatively small furnaces, well below $1 per ton of steel, are not unusual. The flame arc also leads to another important cost saving, in that with the flame arc the amount of current used in amperes is only a small proportion, from one-fifth to one-sixth of that required with the spot arc type having a high power factor. This means that the electrode consumption per ton of steel is very low. In no case with the flame arc type of furnace, is the electric consumption over four pounds of electrode per ton of steel, and in some cases of well-handled furnaces, it has been well below three pounds per ton of steel.

In again commending Mr. Morrison for the valuable data in his paper, it may be well to point out that the increased

speed at which the installation of electric furnaces in steel plants in the United States is coming about, is due to the fact that the cost of operation per ton of steel has been enormously reduced in the last few years by the introduction of American-designed furnaces, and that it is this difference in cost which is the important factor in determining the installation of an electric furnace in any foundry. It may be safe to take it for granted that practically any type of electric furnace will make good steel, the quality depending on the skill of the melter.

The matter of prime importance for American foundrymen is that electric steel can now be made cheaper than steel can be made in any other way for production of equal tonnage.

MR. W. R. BOSSINGER:—I would like to ask if one could recognize any difference in the tensile strength, in say 0.15 carbon electric steel as compared with basic open-hearth, and if there would be any difference in the analysis?

MR. W. L. MORRISON:—As a rule, electric steel will show an increase in tensile strength of 20 to 25 per cent over steel made in the open-hearth, but in comparison with Bessemer steel I could not state. I think one reason for this higher tensile strength is less tendency to segregation in electric steel. Then too, there is a property in electric steel that they don't seem to fully agree to, and that is the intimate mixture of the carbides of the iron and certain formation of alloys. This is not definitely understood on account of the high temperature of the arc when these are produced. That is one reason assigned for the greater tensile strength. I cannot say whether that is so or not.

MR. F. T. SNYDER:—We have done some experimental work along that line. It is quite well-known that a molecule is a flat substance like a poker chip and in alloy steel the molecules are headed in all directions. When an electric current is passed through the steel in a molten condition, the tendency seems to be to turn some of these molecules around so that the planes of the poker chips are parallel to each other. This happens to a certain extent when steel is magnetized. The result is the tendency of the molecules to pack up closer and the packing of things together flat-ways means

a stronger structure than when they are jumbled in a heterogeneous method. This is simply a suggestion. It is a possibility that some action of this sort due to the passing of the current through the liquid steel accounts for its somewhat higher tensile strength.

THE CHAIRMAN, MR. R. A. BULL:—Mr. Morrison stated that the increased tensile strength was about 25 per cent. I would like to ask him what, say for 0.20 carbon steel, would be the representative physical characteristics?

MR. W. L. MORRISON:—There have been so many tests made that I could not answer that offhand. I haven't the data with me. I could however communicate it later from data in my files.

MR. PAUL KREUZPOINTNER:—This question of the increased tensile strength of electric steel is a very important one, and from what experience I have had with the testing of steel, I would say that this increased tensile strength is due to increased density, and the increased density of the steel is due to freedom from the absorption of gases in the electric furnace as well as to the absence of impurities such as slag and other things which get into the steel in the Bessemer as well as the open-hearth furnace. Thirty-four years ago I began my first microscopical investigations in steel. There were then only plain carbon steels. Nickel was the first addition, and nickel steel was praised for its higher tensile strength and increased elasticity. My early investigations led me to think—this was confirmed afterwards—that the meritorious effects of the nickel were simply a condensation of the steel, a smaller grain and a greater density. The smaller your grain and the denser your structures in the steel, the greater your tensile strength will be. In all these years in continuously comparing carbon and alloy steels, both Bessemer and open-hearth (while personally having little to do with electric steel), I have noticed that nickel, aluminum and certain other elements, act chiefly in either removing the gases absorbed during the melting or removing the impurities like slag and other additions which get between the crystals and prevent the cohesion of the crystals and thus indirectly produce an

increased density. Investigations in this country as well as in European countries, notably in France by Dr. Osmond, have confirmed the conclusion that the merit of these additions and the merit of electric steel is due largely to increased density and the cleaner we get the steel from occluded gases and from slag and other impurities, the greater the density the greater the tensile strength and elasticity will be. Let me call your attention to one point in this regard, to the early specifications of the German railroad when Ruella, the German director and scientist, prescribed specifications for all steel accepted in those days, tensile strength plus contraction of area. Now this specification died of inanition, but in those days the steelmakers were very much bothered by this contraction of area specification. The specification was tensile strength plus contraction of area must be 100 and not less than 95. In other words, if the tensile strength was 50, the contraction of area could not be less than 45 or 50. If the tensile strength was 70, the contraction of area was to be 25 or 30. I remember saying to one of our steel makers in this country concerning some government and other specifications, "How do you get around the contraction of area?" "Well," he replied, "we get around somehow." The addition of silicon produced an increased density and this increased density produced that desirable degree of contraction of area. Trouble was experienced in European steel made for railroad and other government uses, for the addition of silicon produced an increased abrasion of wear of the steel, and as early as 1888, the German Society of Iron and Steel Makers opposed this specification because it put them between two fires. They were expected to make steel resist a certain amount of wear and tear and have a certain amount of contraction of area and they could not get that contraction of area by density and meet all the requirements of the government. As early as 1888, they protested against that specification and in the course of time, it died. What we have obtained through the use of the electric furnace is greater density in the steel, causing an increased tensile strength and elasticity. The electric furnace prevents, to a large extent, the

absorption of gases and makes the steel cleaner by washing off slag, bricks, etc., off of the steel.

THE CHAIRMAN:—I don't want to prolong this discussion unnecessarily but I think there are a good many of us who would really like to obtain information as to the average physical characteristics of electric steel. Those of us that are not engaged in electric steel manufacture have heard many general statements about the superior qualities of electric steel, and reasons have been frequently assigned for these superior characteristics, but I have seen very little data as to the average physical results so that the open-hearth man or the converter man can make his own comparisons. If there is any one in the audience who can briefly give us any figures, I am sure we will all appreciate it. Mr. Snyder, can you give us any data?

MR. F. T. SNYDER:—Mr. Baldwin has much more than I have. I would suggest that we hear from him.

MR. R. L. BALDWIN:—We find that tensile strength is very little greater in electric steel than in ordinary steel, but the noticeable feature is the increase in the elastic limit which approaches 60 or 65 per cent of the tensile strength.

THE CHAIRMAN:—Mr. G. J. Stock was to have discussed Mr. Morrison's paper by previous arrangement, but I have a letter from him from Darlington, England, in which he states that he could not oblige us on account of the war situation. For the same reason, Prof. T. A. Louden, of Toronto, Ont., has found it necessary to disappoint us. He was to have a paper on "Making Steel Direct from Ore in the Electric Furnace."

Ganister Lining in Side Blow Converters

By JOHN GREGSON, Milwaukee.

A great deal has been said and written about side blow converters, both in praise and condemnation. Every steel maker is familiar with Mr. Simonson's excellent little volume on the subject, and will recall that he advocated a ganister lining. The occasion for this paper is a remarkable run made recently by the Sivyer Steel Casting Co. when using a complete ganister lining in its one-ton converter. Twenty-three blows were made in a single day; 30 blows were made in two consecutive days the following fortnight; and 203 blows in 13 blowing days in June.

Now the vital problem in side blow converter practice is the lining, and it must never be forgotten that the lining of a converter has to be more than heat resisting. The fact that silica brick are used in open-hearth furnace construction is no reason that they are the best material for side blow converters. The function of an open-hearth roof is to reflect heat, and it is never called on to stand the cutting action of the oxides formed during refining. The converter lining, on the other hand, must resist a greater absolute temperature than the open-hearth roof and at the same time be subjected to direct contact with the oxides. The actual conditions under which the oxides are formed are different in the two furnaces. In the open-hearth the source of temperature is a gas or an oil flame and the reactions take place slowly under the eye of the melter, the amount of heat given off by the oxidation being negligible. Consequently the furnace is always hotter than the bath. In a converter, the forming of the oxides produces the temperature and the reactions are quick. Also the heat, after the carbon flame, is augmented by the burning of CO to CO_2 and is far greater than in an open-hearth furnace. Hence the converter lining is at a lower temperature than the

bath and subjected to a more severe test than is the lining of an open-hearth furnace. Furthermore, in a one-ton converter, owing to the smallness of the bath and the consequently more rapid changes in the metal level, the reactions have a much more marked effect on the lining than in larger converters.

For three months after the installation of a one-ton converter the practice was standard. The converter was lined with silica brick and brick tuyeres were used. The bottom was knocked out at the end of each blowing day. Repairs were made with a mixture of silica grits, silica molding sand and fire clay. With that practice, eight to ten blows a day were made, and all the metal was taken from the converter in hand shanks. As time went on it was noticeable that the amount of repairing material used was increasing from day to day. In chipping away the slag, pieces of brick were frequently loosened up and fell out, until finally there were no brick left just above the slag line and on the back side. Burns through occurred and heats were scrapped. It was evident that the repairing material was not of sufficiently refractory nature to allow an average of ten blows a day to be maintained.

Ganister Mixture Tried

It was decided to try a ganister mixture for repairs, and one was procured with a rock base that ran about 99 per cent silica, crushed and mixed with specially prepared fire clay. The first day's trial proved conclusively that the move was in the right direction, and a ganister lining throughout the converter was substituted for the original one of brick, which was in very bad condition after three months of service. This lining held up so well that it was found practicable to leave the bottom in for two or three days. By running the blower at low pressure for three or four hours at night, the converter was cooled sufficiently to allow a man to stay inside long enough to affect small daily repairs, and an average of ten blows was easily maintained. At that time more metal was needed, and to speed up operations the finished metal was poured into a large ladle and shanked from that. This is standard practice, of course, in two-ton converters, but the one-ton converter

was unable to stand up under the strain, with only a few minutes between blows. A repetition of the trouble originally found in the silica brick lining took place. In order to further increase the refractory nature of the mixture, a small amount of crushed rock without any fire clay was added to the original mixture, and after a few trials a combination was secured which allows practically continuous blowing.

These facts are brought before you as matters of interest because the use of silica brick in converters is nearly universal, and it is hard to see a reason for it unless it be that the proper ways of using ganister are so little known that men hesitate to experiment after one or two failures. Only a few shops use ganister entirely, most operators having some pet repairing mixture which they apply on a foundation of silica brick.

Perhaps one difficulty for the beginner is the necessity of finding a substitute for the customary brick tuyeres. A plate may be made to bolt over the opening onto the wind-box, with bosses drilled and reamed to hold pipes. Great care must be taken to have the center of the holes come in the same plane, as it is essential to have the tuyeres level and plumb when the converter stands vertical. Such a plate can be made to fit any style of converter.

The tuyeres having been set in an empty shell, patterns have to be made in accordance with the shape of the converter, for ganister must be rammed, not mudded on. In a vessel that has a removable section, permanent forms are cheapest. On a drop bottom converter, rough lumber can be knocked together and then burned out. In any type of shell it is advisable to use the rough timber in the bottom or tuyere section, as frequently drawing out of a form disturbs the ganister around the tuyeres. The ganister itself should be put in around the forms, in small quantities, and rammed solidly and evenly with an air rammer, except at the tuyeres. At that point the greatest care must be exercised and it is better to use the pein end of a hand rammer.

The cost of the original linings in a one-ton converter will show little difference between silica brick and ganister, but there

is a big saving of time and material in the daily repairs by the latter method. When the tuyeres are badly burned away, the old pipes can be drawn out and replaced by new ones, which is a distinct advantage over the old way of ramming ganister around a stick. There is always a soft spot where the patch joins the old lining and the air gradually blows the hole bigger. In one shop where a two-ton converter with a ganister lining is used an average of eight blows, five days a week, has been maintained for months. It is frequently possible to run an entire week without touching the tuyeres, and no repairs inside the vessel save small patches on the belly. In a one-ton converter the same bottom and tuyeres often last four days with an average of thirty to thirty-six blows those four days.

The greatest saving of all, however, is in the peace of mind of the blower. It is not nearly so easy as it looks to turn down blow after blow correctly, and it should always be kept in mind that 95 per cent of the results are not up to the converter itself, but to the operator. When the lining stands up the nervous tension is reduced to a minimum, and the answer is good steel for the foundry.

Discussion

THE CHAIRMAN, R. A. BULL:—The performance of the side-blow converter that Mr. Gregson has described is very interesting. We would be glad to have some comments on it.

MR. LIPERS:—I would like to ask after you had transferred the metal into the ladle whether the metal was sufficiently hot to pour for light work?

MR. JOHN GREGSON:—Yes, sir.

MR. W. L. MORRISON:—In pouring from that large ladle, what would be the average number of shanks you'd get from one ladle? That is, how many times could you use the same ladle from that one heat?

MR. JOHN GREGSON:—We use our shanks practically all day.

MR. W. L. MORRISON:—Don't they skull?

MR. JOHN GREGSON:—The skull is cleaned out.

MR. SWEET:—I would like to ask Mr. Gregson in what proportion should clay be used as a binder with the ganister?

MR. JOHN GREGSON:—Of course the more clay you have in the ganister as a binder, the less refractory, so the proportion of clay is limited to the plasticity of your ganister. You have to have enough clay so you can handle it and no more, and that you will have to find out for yourself. It runs somewhere between 5 and 10 per cent of clay.

General Melting Characteristics of Acid Steel for Castings

By A. F. Stirling Blackwood, Detroit.

Acid steel is melted and refined in a crucible or furnace having a siliceous lining. As this comprises crucible, converter, open-hearth and in some cases the electric furnace, the melting characteristics of each shall be described in the order named. Previous to 1856 there were only two steels in the market, namely crucible or cast steel and blister steel and although this steel was only used in the forging of special cutlery, still the melting hole used then was the same as the coke furnace of today. The earliest form of crucible steel furnaces for melting crucible steel for castings were the same as used by Huntsman of Sheffield and consisted of a melting hole which was a rectangular chamber 3 feet deep and about 2 feet square lined with fire brick. The top of the furnace was on the floor level and was covered with square fire brick set in an iron frame provided with a handle used for moving the cover. The grate bars and pit were beneath the floor, and each hole contained four pots which were placed on top of a layer of coke. The pots were charged and the furnace filled with coke which was tampered all around the pots and filled to the top of the furnace, which was generally about 8 inches above the top of the pots. One stack provided draught for about 12 melting holes. The steel castings poured from this type of furnace are very different from the crucible steel castings as made in this country from oil and gas-fired furnaces, being a very high carbon material similar in composition to the so-called malleable steels made in air furnaces and cupolas. It was from this type of furnace that the metal thus described was first made. The castings from this process are accepted by some of the foreign governments and come under steel castings classed as "C." The requirements which these castings have to

meet, consist of a 12-foot drop test on a heavy steel plate. This metal can be cast in very light sections and the castings, after annealing are very ductile and smooth. The mixture consists of 30 per cent low phosphorus, high silicon iron, and the balance steel punchings. When cast, the metal is white, similar to malleable iron and is annealed at a very high temperature without packing. Tests of this material show a tensile strength of about 60,000 pounds per square inch with practically no elongation and reduction of area. This metal is melted in plumbago pots which run about 20 heats per pot.

Practice in this Country

The crucible steel made in this country is nearly all melted in the oil-fired furnace, which is simple in construction. There are several types in use melting 2, 4, 6, and 8 pots at one time. The most common type is the 6-pot furnace, having a combustion chamber in front of the melting hole, in which the oil is burned with the amount of air necessary. The air is controlled by damper plates on top of the chamber. In most types the oil is run into a series of pans, the flame then being carried into the furnace by natural draught, the sole aim being to get complete combustion of the hot gases in the melting chamber. The wear on the pots is most severe and their average life is 3 heats. This, together with the high melting cost, makes the manufacture of crucible steel almost prohibitive. The oil fired furnace is well suited to intermittent operation and gives on an average three heats per day.

The most common type of gas-fired furnace is the Siemens regenerative, using either producer or natural gas and below the melting chamber is built similar to the old type of open-hearth furnace having the gas and air chambers immediately below the melting chamber and supporting the furnace proper. In the center of the furnace is a depressed trough on which the pots are placed in pairs. The furnace chamber, like the ordinary melting hole, is placed below the floor level and the movable arch covers only are above the

floor the same as the coke-fired furnace. The regenerators are built on either side of the melting hole of the furnace, the heating chamber itself thus standing in a trough between the two pairs of regenerators. The furnaces are rectangular in shape and are constructed to hold from 12 to 24 crucibles, arranged in pairs and each pot carries a charge of about 120 pounds. Each hole is covered by three movable tops forming the roof, while the side walls of the furnace incline from the bottom to the top, making the same taper from 3 feet at the bottom to about 2 feet at the top. From five to six heats are easily melted in 24 hours. Great care has to be taken in handling pots as they are easily broken when ready for pulling. The bottom of this furnace is covered with coke breeze over an iron plate. The plate is provided with an opening so that if any of the pots break while melting, the bottom is punched through and the spilled metal is allowed to run into the pit beneath. Air hoists generally are employed to draw the pots, as this allows quick working and eliminates the trouble of finding suitable help for pot pulling. When working on producer gas and the melting is carefully watched, a furnace of this type can run with a consumption of one ton of coal per ton of steel. This furnace can produce steel much cheaper than the ordinary, coke-fired type, but owing to the high cost of installation, it has not been used extensively in foundries in this country as the oil-fired furnace can be installed at a lower cost and requires less skill to operate.

A new type of oil-fired crucible furnace was introduced some years ago, but never found favor with steel foundrymen, due no doubt to the radical change in design and also to the difficulty of removing the pots. This furnace was designed in Sweden and the writer certainly lost some sleep trying to make steel in this melting medium. It was similar to the Krupp furnace, which is merely a flat bottom, open-hearth furnace without checkers, having doors along the side. The pots are set in the furnace and pulled out by means of long, horizontal tongs suspended from a trolley. Unlike the Krupp furnace, it was oil-fired with two high

pressure burners entering from each end with a series of openings in the brickwork through which air was forced at a very low pressure, after passing through a series of coils in the flue and being preheated to about 400 degrees Fahr. The bottom of the furnace was covered with silica sand and gradually sloped towards the center through which any spilled metal was expected to run out into a pit. Unfortunately the pots broke faster than the metal could run out and the bottom soon became covered with steel which had to be pried off the bottom with bars, and the side of the furnace had to be taken down to remove the scrap. After several attempts this furnace was abandoned and I doubt if any further attempt has been made to run it.

American Crucibles

The pots used in this country are made entirely from plumbago and in good practice average three heats. It is necessary that they be thoroughly dried before annealing and they usually are placed over the top of the furnace before being used. They produce extremely hot metal, well suited for small and intricate castings and should be very pure as regards oxide, etc. Chemically, the metal is hard to regulate owing to the fact that the material used consists almost entirely of boiler plate punchings, which frequently are mixed with high phosphorous and high sulphur scrap and the absorption of carbon from the plumbago crucibles also affects the chemical contents. The common practice is not to cover the crucible while melting and the oxidation is much greater than is commonly believed and brings home to us the fact that the methods used for melting crucible steel for tools and that used for steel castings are very different. The ordinary crucible steel casting of today is physically very poor steel. The high cost of melting, together with the development of the baby converter and the electric furnace for small steel castings, in recent years almost has eliminated the crucible steel process. The melting procedure is simplicity itself and consists of heating the furnace, and charging pots with punchings, care being taken that the

pots are not too full, as when the metal melts it may run down the side of the pot, cutting it and thereby losing the charge. Proper combustion is necessary in the melting chamber to bring the steel to a high state of fluidity, which is tested by pushing a rod through the molten metal. Finally the deoxidizers are added and the metal is poured. There is little or no skill required in crucible steel melting, and an ordinary laborer can be trained rapidly to become a skilled melter. When making alloy steel such as that containing chrome, nickel, or vanadium the alloys are charged with the scrap and melted down with the charge.

Summarizing, we can claim for crucible steel for castings great flexibility, poor quality, low cost of installation, suitability for small work, and maximum melting cost. It is one of the most talked of products in the steel foundry, and one of the most abused and least understood.

Converter Process

The Bessemer or converter process has almost superceded crucible steel practice for the manufacture of steel for small castings and it may be well to state here that the converter process is only adapted for small steel castings and should not in any way be compared to the open-hearth. To the writer's knowledge there is only one converter plant which is able to compete with the open-hearth. In 1856 Bessemer startled the world with his paper entitled "The Manufacture of Malleable Iron and Steel Without Fuel" at the Cheltenham meeting of the British Association, and on his recognition of the Mushet patent on manganese as an addition, the process has not been appreciably modified. The direct refining in his process is easily understood, the air passing through the bath under pressure oxidizing first the iron forming oxides, which, in turn, are reduced by the impurities to be eliminated.

The refining process is divided into three distinct stages or periods: First, the slag forming period; second, the boil and third, the finishing period. These may be described as

follows: First, the silicon begins to burn and sparks due to this combustion appear at the mouth of the converter. During this period the manganese begins to burn also and the graphitic carbon in the iron is converted to white iron. The duration of this period is governed by the percentage of silicon in the bath, temperature of bath, and air pressure. The second period begins with a white flame gradually increasing in density and volume, the carbon in the iron begins to burn giving a mixture at the mouth of the converter of CO and CO_2. The manganese is all oxidized during this period, sometimes accompanied by violent boiling due to the oxidation of the carbon. In the third stage the white fumes become red, due to the burning-out of the metalloids, and great care has to be exercised or there will be a great loss due to the formation of FeO. When the flame has dropped, the converter is tilted to a horizontal position, the blast is shut off and the vessel contains a pure iron, high in oxides, but containing small amounts of carbon, silicon and manganese. A mixture of ferro-silicon and ferro-manganese then is added to the bath, which fulfills the double mission of reducing the iron oxides and recarbonizing, resiliconizing and remanganizing the bath. The only method used today for ascertaining when the blowing operation is complete, is by the examination of the flame, and so distinct are the three periods and reactions, the signs indicating the end of an operation are absolutely unmistakable and operators can be trained to be absolutely reliable in a very short time.

Starting from the time when the original Bessemer converter was blown from the side near the bottom until Tropenas conceived the idea of blowing on the surface of the metal, many methods were tried between those points, with more or less success to meet the requirements of the steel foundry, and in the early types such as the Clapp, Griffith, Walrand and Roberts converters the tuyeres were placed below the metal at various depths. The original type of Bessemer converter required very large blowing engines due to the high pressure required. The true, bottom-blown con-

verter has been little used in the foundry, due no doubt to the same disadvantage as that which existed in the early type, side-blown vessels, namely the high pressure required for blowing. To the writer's knowledge there is only one in use today in a foundry doing general open-hearth jobbing work, and how it can exist is a question difficult to answer.

The procedure of manipulation is similar to the general Bessemer practice and the vessel consists of a plain, cylindrical shell with tapered nose built in one piece, with the exception of the wind box and bottom which are removable. The vessel is mounted on trunnions, the blast entering one trunnion and passes through a pipe at the side of the vessel. The blast pipe is connected to the wind box with a removable coupling. The vessel is lined in the usual way, gannister being rammed around a form and the lining built up to the required diameter. The tuyeres must be carefully selected and should consist of the best grade of silica brick, as the life of the bottoms is very short.

The side-blown converter is used almost exclusively in foundries, but differs little from the Bessemer converter in outline. However, the method of applying the blast is different, the pressure required being much less, at no time exceeding 5 pounds. It also can be used in much smaller units, namely from 1-2 ton up to 5 tons. The first true type of side-blown converter, namely one in which the air is blown across the surface was the Tropenas and as this type is universally used either in the original or in modified forms, we shall confine our remarks to it.

Tropenas Converter

The original side-blown converter, as conceived by Tropenas in 1900, was similar to the standard converter of today, with the exception that the bottom was conical in shape, the idea being that the bath of metal should present as large a surface as possible to the blast and at the same time not be too shallow. By having a deep bath the metal was kept as still as possible and was not violently agitated as

in the previous methods of blowing. The vessel was also provided with two sets of tuyeres, one set above the other. The bottom row were known as the tuyeres of reaction, the oxidation taking place on the surface only. As soon as the flame appeared, air was admitted through the top tuyeres to burn the CO to CO_2, the idea being to assist the bottom tuyeres. In practice, however, it soon was found that the top tuyeres became clogged with slag, and they since have been eliminated.

The modern Tropenas converter has a flat bottom and the lining below the tuyeres now is made straight with a deep bath. The converters generally used have a capacity from 1-2 to 5 tons, the most familiar types employed being of one and two tons capacity. Since the one-ton vessel has proved so successful for very small and intricate castings, converters of this capacity have become very popular. In the treatment of a small charge like that in the one-ton type, the loss of heat in comparison to that in larger units is high and the least error on the part of the operator leads to an irregular blow. For small castings, the steel obtained at the end of the blow must be at a high temperature so that it will retain its fluidity long enough to be poured into the molds in small ladles and be cast without haste. To insure hot metal, Tropenas conceived the idea of adding silicon during the blowing and this practice is the subject of a patent taken out in 1908 calling for the addition of silicon when the carbon flame appears. This method is universally employed by all users of the small converter, but there is some question as to the validity of this patent, as in the early Walrand process it was quite customary to add silicon during the early part of the blow. It also was used in Sheffield, but at no specific time, and was employed only as a warming-up medium when the steel appeared cold during the early stage of blowing. The success of adding ferrosilicon is no doubt due to the fact that the heat of oxidation of the silicon is rapidly evolved, caused by the quick reaction in the converter with a large air volume and small mass. Adding silicon when the carbon flame appears also permits

the use of a low silicon iron, thereby practically eliminating the first period, and obtaining a very short secondary period with high evolution of heat and a very distinct drop of flame. The periods being short (about 12 minutes altogether, with a low blast pressure) very quiet blows and extremely hot metal with a very low oxidation loss results.

Importance of Cupola Melting

Steel making by the converter process depends a great deal on good cupola practice, whereby suitable metal is secured for fast working. The cupola should be of the high well type, single tuyered if possible, the tuyeres being arranged in a continuous ring. Many objections have been made to the high well cupola for the reason that the molten iron absorbs sulphur from the coke, but when the cupola is run so fast that it is not necessary to shut off the blast, the danger of absorbing sulphur is minimized. Sufficient iron should be tapped from the cupola at one time for a full blow. The iron should be clean and hot and any saving attempted in cutting down the coke consumption will manifest itself in the operation of the converter. Since the cost of pig iron used in converter practice is high, as much steel scrap as possible should be used, and in a cupola that is kept well slagged, 50 per cent steel scrap can be charged with a 6-1 coke ratio. This will insure clean, hot iron with a low silicon content, which from experience I find gives much quieter blows than high silicon iron, due no doubt to the quick reaction and highly fluid slags. One important point is to see that the analysis of the iron is kept rigidly constant, which easily can be obtained by using correct care in charging, placing the scrap burdens properly and keeping the slag spout open.

Successful operation does not require a high degree of skill, but strict attention to the small details and taking nothing for granted will insure good results. It is important to see that the proper amount of metal is added to the converter before blowing; that the tuyeres are correctly planed to the surface of the metal; that the air coming from the

blower is at a constant degree of dryness; that the tuyeres are clean, and that the analysis of the charge is constant. Then if the blower is in harmony with his work, the steel must be right. Almost any grade of low phosphorous pig iron can be used, either in the form of sand cast or chilled pig, and the pigs should be broken so as to prevent scaffolding in the cupola; also when ferro-manganese or ferro-silicon is used in the cupola care should be exercised to insure the passing down of this material evenly with the charges.

All the shop scrap should be used from day to day and if running 50 per cent scrap, the balance of the charges can be made up of low phosphorus purchase scrap, for if a converter foundry cannot use up all its own scrap, there is something wrong and this should be investigated immediately.

Use of Copper in Iron

The use of copper in iron, which has been so strongly opposed by the users of steel, has become general in converter practice, as it has been found by investigation that the presence of copper in steel, up to certain limits, does not injure the metal, but rather increases the tensile strength and elastic limit without sacrificing elongation or reduction in area. It is the customary practice to pour the steel direct from the converter into small ladles, the converter serving as a ladle keeping the metal hotter than when poured into a large ladle, and by the aid of a special fire brick placed in the mouth of the converter the slag is kept from mixing with the metal when being poured. This facilitates the slower pouring of the molds, which helps to make sound, clean castings with small waste and metal loss. The vessel either is lined with silica brick or ganister and most foundries seem to favor the ganister lining. This consists of mica schist grits and fire clay tempered with molasses, and it has been found that molasses as a temper gives the best results. The harder the ganister is rammed, the longer the lining will last. It also has been found that using

straight silica sand with fire clay and molasses makes an ideal lining which lasts longer than mica schist grits, but the objection to this lining is that it smooths over like the bottom of an open-hearth furnace and the patches having nothing to grip to, will not stick. When lining with silica brick, 9-inch squares are placed on end on the bottom, the side walls being made of 1, 2 and 3 side arch brick to the tuyeres, end arch brick on the tuyeres, and side arch brick to the top. By using side arch brick we get a double ring and when the inside burns away, ganister can be rammed against the outside ring for an indefinite period, thereby prolonging the life of the lining and materially increasing the output.

The Tuyere Problem

Two kinds of tuyeres are used and each has its respective merits. The oldest type is the brick tuyere which is composed of five or more tuyere brick made of the best silica material, slowly and carefully baked. These are made to conform to the pitch of the inside lining. Great care has to be exercised in placing the tuyere blocks, to see that the holes are in the same plane, but after the helper becomes experienced in placing them in position, this can be done rapidly and accurately. From my experience in converter practice I favor the brick tuyeres and 500 to 600 blows can be obtained from one set of tuyeres. They are easily patched, and by placing a bar in each tuyere and ramming ganister on the face, they will last as long as any lining. In many converters the brick tuyeres have been replaced by iron pipes, which are rammed up in position with ganister and are left in during blowing. As they burn off, they are pushed further in and a new piece of pipe is backed against the end. It is claimed that the pipes keep the ganister solid around the tuyeres, but it should be remembered that the pipes will burn off faster than the lining and will flux the lining when the air pressure strikes the metal. The pipes do not last as long as the brick tuyere and require more attention. Furthermore, if by accident the blast should go off when blowing, the iron will run into the tuy-

eres before the operator has time to turn down the vessel, causing the danger of the metal fusing in the pipes and stopping-up the tuyeres, whereas, with the brick tuyeres the metal can be punched in with a chisel bar. The final addition, in all cases, should be made in a molten condition and this can be done easily by having a small crucible furnace at a convenient point close to the converter with sufficient capacity to melt the ferro-silicon and ferro-manganese as fast as required. Molten additions not only insure greater uniformity in the finished steel, but cut down the amount necessary to thoroughly deoxidize and to give the desired analysis. By cutting the flame short it is not necessary to make a final addition of iron to the blow, but the better practice is to blow down and add the iron together with the ferro-silicon and ferro-manganese in the molten condition, as by melting the iron with these alloys, the melting point is lowered. The output of a converter is almost unlimited and as many as 23 blows have been taken in 8 hours from a one ton vessel averaging about 1700 pounds each. The usual methods of heating the converter before blowing are by coke and the oil burner. When using coke a wood fire is built in the bottom of the converter and the blast is turned on slightly. Then the coke is thrown in until the converter is full and the pressure is increased. The mouth of the converter is lowered occasionally to the bottom position and the wind box door is opened to allow the flame to come through the tuyeres and heat the bottom. This method is expensive and slow and the oil burner has practically superseded the use of coke in heating. Heating by oil is best accomplished by introducing through the tuyeres, oil under pressure, by means of small pipes about ⅛ inch in diameter, and the air for combustion is blown through the tuyeres at about 2 pounds, the pressure enveloping the oil pipes and giving an intensely hot flame. By regulating the oil we can obtain almost any temperature and can heat up a vessel ready for steel in 15 minutes. Since the converter metal is practically pure iron, at the end of the blow, there is no other known process by which dynamo

and the general line of electric castings can be made so satisfactorily. The chemical analysis of this steel averages silicon, 0.10 per cent; manganese, trace, and carbon, below 0.10 per cent. This is practically wrought iron free from slag. To produce such metal and to pour it into molds requires such a high temperature that this only can be attained in the converter.

Producing Special Steels

In the manufacture of special steels the procedure is simple. Since the converter metal is practically pure iron, nickel, chrome, vanadium and other alloy steels of varying percentages, low in carbon and silicon, can be obtained easily by changing the proportions of alloy additions. The alloys are added to the metal to the best advantage after the ferro-silicon and ferro-manganese additions have been made, but in making small quantities, the alloys can be added readily to the metal in the ladles as the high temperature of the metal permits that practice. In the case of titanium steel, the ferro-titanium has to be added carefully. The slag on the metal should be pushed back before throwing the titanium alloy into the vessel, and by placing the alloy in tin cans this can be done successfully. The new alloy, aluminum-titanium, entirely eliminates all this trouble and can be added direct to the metal in the small ladles.

Manganese Steel

Manganese steel is made successfully by the converter process, both here and abroad, and this is the method recommended for this important branch of the steel foundry industry. The procedure is simple, the metal being refined in the usual way in the converter. After the vessel is turned down, the metal is poured into a ladle containing the requisite amount of ferro-manganese previously melted in a crucible furnace. The ferro-manganese acts as a strong scavenger, removing oxygen and other impurities from the metal and leaving it very dense and homogeneous.

Many methods for eliminating phosphorus and sulphur in the acid converter have been tried, the latest providing for

the use of manganese sesquifluoride which is added to the converter after the silicon in the metal has been burned out. These salts are heated before being added to the metal. According to M. L. Goldmerstein, the inventor of this process, it has successfully been applied in a steel foundry in Pennsylvania. The cost per ton for refining by this method is about $1.50, which, however, is quite a large burden to add to any melting cost. By judicious and careful fluxing in the cupola, the sulphur, at no time need exceed more than 0.05 per cent in the finished steel and this can be attained without extra expense; therefore, there is no need for special fluxing in the converter.

It has been found in practice, that owing to the high temperature at which the metal has to be poured to run thin sections, the wear on the lining is most severe and it is impossible, with the ordinary converter, to get the maximum output and run continuously without having to shut down for repairs. The expense is heavy, due to the time it takes for cooling and in general practice, to produce steel every day, it has been found necessary to have two converters which are operated alternately, one undergoing repairs, while the other is blowing. To overcome this difficulty, three new types of converters have been placed on the market, namely, the drop bottom, removable bottom and the two-piece or removable top converter. The drop bottom converter, as designed by Tropenas, consists of a double door-bottom, similar to that with which cupolas are equipped. After blowing, the doors are opened and the lining forming the bottom of the converter is knocked out. The opening permits the air to circulate freely in the converter, and practice has shown that the lining cools off with sufficient rapidity to permit of making repairs the following morning. To use the converter again, the doors are closed, the bottom lining is rammed up and the converter is ready to be heated. The only objection that may be raised against this type of converter is that in small capacity vessels there is so little space, that it is difficult for a man to stand inside the vessel and ram the ganister hard enough, as it is a well known fact that the harder the ganister is rammed, the longer the lining will last.

The removable bottom converter, as designed by Stoughton, is built to permit the removal of the bottom together with the wind box and tuyeres. This feature also facilitates the rapid cooling of the vessel and relining, but the removal of the wind box and bottom is a troublesome operation and takes much time.

Removable Top Converter

The two-piece or removable top converter as devised by Blackwood is split through a plane immediately above the tuyeres, where the greatest wear occurs on the lining. This plane is located immediately above the trunnions. The bottom half carries the trunnions, which are cast with the ring that encircles the bottom half of the converter shell. On the top flange of this ring are six shackles spaced equidistant, which enter a slot of a bracket on the top half and a key is driven through the hole on the head of shackle, thereby firmly securing both parts. On the top half are four eye-brackets through which are passed the chain hooks for lowering or lifting this part. Two trunnions also are bolted to this part in line with the main trunnions of the converter. When the top half is being cooled and repaired it rests on a special frame having two journals, which permits the top part to be swung in any direction greatly facilitating the making of repairs. Immediately after the last blow, the top is lifted off and swung onto the frame and the converter is cool enough to repair in four hours. The bottom half is brought to a horizontal position and the condition of the tuyeres is observed at once. The converter is repaired every morning, a pneumatic rammer being used for ramming the ganister. The converter then is put together and is ready for blowing by 10 a. m. The total time of one man for making repairs, closing and heating, is only three hours. I know of two converters that have produced nearly 20,000 blows and not once has a day been lost due to the vessels not being ready for blowing.

Stock Oil-Fired Converter

Recently there was introduced in this country the Stock oil-fired converter which deserves mention. This is a com-

bination of an oil melting furnace and side-blown converter, the pig iron and scrap being charged cold and melted with oil burners extending through the tuyeres. When the charge is melted the vessel is turned up and blown in the usual way. The mechanism of the converter is such that it can be rotated for receiving the charge, turned to such a position during the melting period that the hot gases from the oil burners are drawn through an economizer which contains the blast pipes through which the blast passes on its way to the converter. The vessel then is rotated to the blowing position and the use of the hot blast from the economizer is said to give a very high temperature to the metal, but it has been already proven in practice that pre-heating the air does not increase the temperature or reduce oxidation. The time per blow varies from two to three hours; therefore it cannot compete with the ordinary converter, which can produce easily three blows per hour. If coke cannot be obtained for a cupola, it would be much cheaper to have a special oil melting furnace for melting down, transferring the metal to a converter and then blowing in the usual way.

Converter steel may be summed up as being preferable for dynamo and electrical castings; the method is the most flexible of all steel processes and is most frequently employed for small steel castings. It is well adapted for intermittent operations.

Open-Hearth Steel Practice

The manufacture of steel in the open-hearth furnace, which we owe to the genius of Siemens and Martin, added to the founder's art one of its most important branches. The process may be divided into three classes: First, the fusion of steel scrap and iron; second, the treatment of pig iron with iron ore and third, a combination of methods involving the melting of steel scrap and pig iron in a bath, oxidizing the carbon, silicon and manganese by iron ore and making the composition to requirements by the addition of ferro-silicon and ferro-manganese. The third process is universally used today and produces steel that meets the most exacting requirements. The open-hearth furnace consists of a large hearth built of refractory material

upon which the metal is melted by the aid of gas and air in proper proportions. The gas can be the product of combustion of coal burned in a gas producer, the atomized gas from oil at a high pressure, natural gas, water gas as produced in the coke industry, or by atomizing pulverized coal as in recent experiments. At each end of the furnace are two chambers filled with checkerwork through which the air and gas pass if producer gas is used. The gas and air pass across the hearth of the furnace and the products of combustion pass through the checkerwork at the other end and then into the stack. This procedure has not changed since the introduction of the process. The producer gas is fed to the furnace very hot, meeting the preheated air for its complete combustion and bringing the bath up to a very high temperature. If not watched carefully, this high temperature will melt the brickwork. At regular intervals the travel of the gas and air is reversed by means of valves, so that the generators are alternately heated up, which in turn impart their heat to the incoming air and gas.

Open-Hearth Furnace Construction

Variations in the details of the furnaces are numerous, but the general construction has not changed much for several years. The body of the furnace should be built of steel plates well supported by buckstays, it should be lined internally with the best silica brick and should be carried on steel girders entirely independent of the regenerator chambers. The checkers should be separate from the furnace proper, with ample slag pockets below the uptakes and holes sufficient for access to the flues. In modern practice the roof is entirely separate from the side walls and many furnaces are provided with bung roofs, which are removed when charging by overhead crane. This permits the use of heavy scrap, which could not be charged through the doors. Channels are carried on the ends and side on which the roof rests thereby allowing ready access to the side walls and end for repairing, which can be done easily. In the old type of furnace, the roof was carried by skewbacks and frequently a good roof has fallen in, due to the

side walls melting down. This was specially troublesome in 5 to 10-ton furnaces. All furnaces now are built above the foundry floor, the tops of the flues only being level with the floor, permitting easy access to the checkers, and also simplifying the handling of the metal. The space between the gas and air flues, or the space between the flames where they pitch to the bath, gives the melter much trouble, due to the arches falling down as a result of the intense heat of the outgoing gases. This is taken care of by having the ports cooled and is accomplished by a built-in frame supporting the bridges through which water may freely circulate.

By having water-cooled ports, water-cooled bulk-heads and water-cooled door frames, the modern open-hearth furnaces remind one of the bosh of a blast furnace and I have often thought there is altogether too much water around the furnace. By cooling a bulk-head port or door, just so much heat is lost to the furnace. Why should we radiate the heat when it costs so much to get it in the furnace? The ports are the only part of the furnace which should be water-cooled, as the construction at this point is of such an intricate and vital nature that it is essential that the relative position of this brickwork remain intact. If the form of the roof is right and the ports are in plane, the doors do not require cooling. If the combustion in the furnace is as near perfect as possible, the flame will travel across the bath at a uniform rate, and the wear on the door lining or frame will not be any greater than on the side wall, and when the door is pulled no flame will come out of the opening. When the scrap is high in the furnace at the first stage of the melting this may occur, but this is the time when the flame should be sharp and lean, for the object is to get the bath slag covered as soon as possible. The warm, waste, cooling water from the bulkhead and port pipes of the furnace is generally supplied to the gas valve hood, instead of cool water, where it is heated still further and then pumped to the boilers. This means a considerable saving in coal consumption in the boilers and to some degree makes up for the heat robbed from the furnace.

One of the most important points in melting is that the combustion of the gas should be as perfect as possible, for not only will the calorific efficiency of the furnace depend upon this, but also the calorific intensity of the flame which is essential for the rapid melting of the steel. The combustion is affected largely by the way the gas and air enter the furnace and this is controlled to a large extent by the position of the ports and the pitch of the roof. The number and position of the ports is a matter of much diversified opinion and is worthy of discussion. The best working furnace that has come under my observation, operating on producer gas, was of 10 tons capacity. It had two gas and one air port, the position of the air port having been midway between the gas ports and the air port was carried on the bridges of the two gas ports. The area of the air port was equal to the two gas ports, with one and one-half times the pitch. This furnace ran for 10 months, taking off three heats per 24 hours, 6 days in the week. The roof was higher than in ordinary practice, giving a large combustion chamber with a fairly deep bath. The steel from the furnace was used entirely on government work ranging from 5 pounds to about 7 tons.

Size of Air and Gas Regenerators

The size of the air and gas regenerators is a much disputed point. The better practice, however, is to have those for air the largest, as the temperature of the air has the greatest influence on the combustion.

Natural gas is used largely in open-hearth practice. When it can be obtained, it is ideal for this purpose, being practically free from non-combustible gases and of such high calorific value, that it does not have to be preheated, thereby eliminating regenerative chambers and it is piped directly to the port, the air only having to be superheated. Fuel oil is largely used, passing into the furnace with air at about 30 pounds pressure.

Use of Tar for Fuel

By-product tar has been tried for furnace fuel, but with little success. It is heated by steam and is forced through the burner at about 40-pounds pressure. It gives intense heat and

if properly applied should be an ideal fuel for steel melting. Water gas is now being used in Germany in the open-hearth with good results, with a fuel consumption of 14 per cent. This gas has to be used with great care, as the high temperature developed by its combustion burns the roof and lining very easily. Pulverized coal is being used to a limited extent. This fuel should be employed without checkerwork as the fine ash carried over will rapidly fill up the checkerwork and flues, and when using this fuel it is essential that the flues be inspected very often and cleaned out when necessary.

Coke oven gas is being used successfully in Germany and according to W. E. Hartman has a heating value ranging from 500 to 650 B. T. U.'s per cubic foot. It is claimed that after the melter is accustomed to the fuel, the wear on the furnace is normal. Among the advantages claimed are higher furnace temperature and more and more uniform combustion. Of the many gas producers on the market, each having its own peculiar function, and each intended to produce the greatest number of cubic feet of gas per ton of fuel, none can assist the steelmaker if the application is not right. Great care should be exercised to insure clean flues, properly placed checkers, uptakes, clean and perfectly tight so that the cold air is not drawn in; gas and air pitching correctly, bottom well-washed and tap hole clean, for after all the steelmaker should remember that the cost of fuel is not nearly so important as that which can be obtained from the fuel.

Layout of Open-Hearth Plant

In laying out an open-hearth foundry, the location of furnaces is often a secondary consideration. This, however should not be so. The furnaces should be situated in a bay near the center of the main foundry so that the metal can be handled easily and quickly, with plenty of space on the charging platform for carrying raw material which should be loaded into the charging boxes on the platform. If gas producers are used, their tops should be on the same level as the charging platform and should form a part thereof, thus bringing all the material to one point. This arrangement centralizes all depart-

ments of the melting floor and enables the chief melter to see that the gas is right, not merely in the furnace, but from the time the coal goes in the producer hopper. All checkerwork should be above ground, so that it can be cooled easily and inspected, ample space should be provided for a charging machine and the building should be high with good ventilation and arranged to suit all weather. Storage should be ample for any emergency and if possible should be on a level with the charging platform.

In lining the furnace, as little clay as possible should be used, to allow for the take-up in expansion, and when building the roof arches, small wooden wedges should be placed alternately between the bricks, so that when the furnace is heated and the expansion begins, the wedges will burn out and provide space for the expansion of the brick; otherwise the roof would be badly warped in many places. After the roof is built, a fine grout of silica clay and water is made and poured over the bricks, so that when the furnace roof is dried and heated carefully, this will glaze over and prevent loose bricks from dropping out. When the furnace is ready for lighting, the air and gas valves should be closed, with the reversing valves on center, to allow a good chimney draught; then fill with wood and light the fire. As soon as the fire is burning brightly, open the gas valve sufficiently to allow enough gas to ignite and keep excess gas on, so that the furnace is smoking. This protects the brickwork and allows the heat to rise gradually. When the temperature is high enough that the flame burns the carbon off the brickwork, it is thoroughly dried and sufficiently hot to prevent the brick from spalling. After a few reversals at short intervals, the air is admitted and the expansion rods are let out gradually until a full heat is in the furnace. The furnace is now ready for making the bottom. If the furnace is oil-fired, care should be exercised to keep the air pressure low, gradually increasing it as the furnace gets warmer, if any spalling occurs, slacken the air; then proceed and raise the temperature to the same point as a gas-fired furnace.

When starting to make bottom, silica brick is stepped-in the angles between the sides and bottom and the latter is made by fusing on silica sand until the required height is reached. The bottom is then washed-out with acid slag which glazes the surface and toughens it. Previous to making bottom, the tap hole is built by inserting an iron rod of the desired diameter at the center of the furnace near the bottom and ramming ganister around it. When it has dried, the rod is withdrawn and the hole is filled with anthracite coal, over which is thrown silica sand. After the bottom is made, the furnace is ready for melting. The tap hole is washed-out and rammed up from the outside with anthracite coal with a ganister backing, a shovel of anthracite is then thrown over the tap hole from the inside of the furnace and this in turn is covered with silica sand. The furnace now is ready for charging.

The Tap Hole

Care should be exercised to keep the tap hole clean and free from metal; it should not be allowed to get too large, should be fairly long, and if this is attended to, the furnace can be tapped any time by one man with a prick bar, as this is the correct way to tap a furnace, and, proportionate to the mass, it should be as easy to tap as a cupola. As soon as the metal is tapped, a bar is pushed through the tap hole from the center door to make sure that it is clear. After the furnace is tapped-out and slagged, the bottom should be carefully gone over with a rabble cleat, so that there may be no wells of metal left, and if there are any, they should be rabbled out with wet sand, for if much metal is left in the bottom, this will be covered with sand when making up bottom and may cause a bad break-out.

Recharging the Furnace

When the furnace is thoroughly drained and the tap hole dried out, the furnace is ready for charging again. If any scrap is left in the bottom below the sand, the metal during a heat sometimes will search it, and violent boiling over this spot occurs. This calls for quick action, as it may cut through the bottom. A boil such as this can invariably be stopped by

dropping a piece of ferro-silicon into the hole. This has a tendency to switch the boil to the ferro-silicon thereby preventing the further cutting of the bottom. In tilting furnaces tap hole trouble is unknown, due to the fact that the tapping spout is normally above the bath at all times, but if the stationary furnace is carefully managed, a hard tap should be as rare as it is in a converter. Building-up of the furnace bottom is due entirely to lack of care in cleaning the bottom and it certainly is no pleasant sight to see an open-hearth furnace melting with a row of bricks beneath the doors to keep the metal in the furnace. Sometimes, without much notice, the roof will fall in. When there is danger of heat breaking through bottom and the metal is liquid enough to run, tap it out even if it runs on the floor, for it is cheaper to break up a bottom outside the furnace than it is to melt it or to take it out of the furnace.

Molten Final Additions

The bifurcated spout is being successfully used and adds much to the flexibility of the process, as two metals of entirely different compositions can be obtained from the same tap. This is accomplished by adding the deoxidizers in a molten condition. Molten final additions are not used in this country, but will be eventually, as the amount of deoxidizers saved almost takes care of the cost of melting. Final additions, when made solid, should be changed in the furnace, as the metal can be well rabbled and when tapped into the ladle the alloys are thoroughly mixed with the metal. Aluminum should be added to the metal in the runner, being fed down onto the metal, as it is being tapped. By the use of a swinging spout, as soon as the metal is all in the ladle, it can be swung out of the way permitting the proper cleaning of the tap hole, which is important, and this makes it much cooler for the workmen. Acid open-hearth steel is best for medium and heavy steel castings both from a quality and economic standpoint, but good melting in the acid furnace is not easy of accomplishment. It requires practical training, skill and care.

The use of electrical energy for the production of heat for steel melting is a comparatively recent innovation. The

device used for transforming electrical energy into heat where high temperatures are required, is called an electric furnace. The ability of the electric furnace to attain temperatures far beyond those hitherto available by other methods, gave it a distinct field of usefulness, in which it did not have to compete with existing furnaces. By the use of these temperatures a new chemistry has been evolved. The electric furnace owes its place in the industrial world to certain characteristics which it possesses and to the advantages which it offers over other means of regenerating heat, the principal one being the high degree of temperature which is made available. It merely requires the passage of the electric current through a conducting medium to produce heat, the intensity of which depends upon the amount of current which passes. Inasmuch as most substances retain their conductivity at high temperatures, the degree of intensity which is electrically possible is unlimited. In practice, however, limitations are placed upon it through the physical difficulties of keeping the conducting medium and the furnace walls in place. Electrical energy gives unadulterated heat to the material, while all other combustion methods involve the transmission of heat by means of their gaseous products of combustion. The efficiency of electric heating, therefore, is greater than any other medium and renders possible a direct application of the heat to the material treated. After many years of experimental work, the electric furnace has reached a position of commercial importance in the steel foundry industry. While the transformation of electric energy into heat energy in itself is a simple operation, there are many modification of furnace construction and operation.

These may be classified as follows: Arc, arc resistance, arc resistance and resistance and induction. The real prototype of the modern arc and arc resistance furnace was devised as far back as 1879 by Sir Wm. Siemens. His arc furnace was capable of melting a few pounds of steel and consisted of a crucible with a refractory lining having an opening on the sides through which were passed two horizontal electrodes, the arc taking place in the center of the crucible immediately above the metal to be melted. This was the forerunner of the present

Stassano furnace and is the only pure arc furnace in use today.

The other electric furnace made by Siemens consisted of a crucible of refractory material with a movable, vertical electrode introduced through a cover on top, the other electrode being a water-cooled iron bar passing through the bottom of the crucible. This type of furnace gave birth to the Girod, Kellar, Gronwall, Nathuseus, Snyder and the common types of today. The principle of the electric application is the same on all the foregoing types, the only difference being in the mechanical details, the placing of the bottom electrode and electrodes and material used for the electrodes.

Arc Resistance Furnaces

In the Girod, Kellar, Gronwall, Nathuseus and Snyder furnaces, we have the representative arc resistance types in use today. The Heroult furnace was the pioneer electric furnace to melt steel for the foundry. It is the only arc resistance furnace developed which differs from the laboratory furnaces of Siemens and here is described as the arc resistance and resistance. This furnace was designed and placed in operation in France by Heroult in 1900. In 1881 Ferraute devised a furnace whereby the molten metal is used to carry the energy which is applied to it by magnetic induction. This original application formed the basis of the modern induction furnace, which aims to use the heat generated in the metal by its resistance, to the passage through it of a heavy electric current. These comprise the Kjellin and Rochling-Rodenhausen which are now combined and known as the Siemens and Halske & Siemens, Schuckertiwerke, Colby and Hiorth.

The pure arc or Stassano furnace consists of a thick cylindrical chamber with a slightly arched roof. The electrodes are introduced through three equidistant openings and project toward the center of the melting chamber. The movement of each electrode is controlled by a hydraulic piston. The source of power is connected by a rod with the end of each electrode, the electrode and electrode holder being surrounded by a water jacket. The latest modification takes a

circular form in which the entire furnace is slightly inclined and rotated slowly about its axis, so as to agitate the bath. This feature is of no value and only adds mechanism, which is a burden to any steel furnace. Due to the long arc the voltage is higher than usual. The advantages claimed are steel fusion by the radiant heat from an arc over the metal in a closed chamber and neutral atmosphere permitting great accuracy in following the specified analysis. The arrangement of the arc permits the carbon and electrode impurities from entering the bath, steady electric demand of the furnace and high temperature. The disadvantages are, limited capacity, high power consumption and slow working.

The Girod Furnace

Among arc resistance furnaces the Girod is used to a limited extent in steel foundries in Europe, but has not been installed extensively in this country. It has a shallow hearth, flat roof with pieces of soft steel embedded in the hearth which are water-cooled. These project beyond the bottom of the hearth a short distance. A water-jacketed electrode passes through the roof, the current being forced to pass through the bath and out through the negative electrodes in the bottom. The advantages claimed are a greater proportion of the heat obtained by resistance, more uniform heating of the bath and low peak-load due to the arc not jumping. The disadvantages are concentrated heating due to the energy flowing along the line of least resistance, danger of burning-out the bottom electrodes thereby losing the metal and the difficulty of keeping a good bottom.

The Kellar furnace is very similar to the Girod and has the same disadvantages. The Gronwall furnace is similar in appearance to the single phase Heroult. It uses two-phase current and has a conducting hearth, the bottom when heated being a secondary conductor. Unlike the Girod, the bottom electrodes are made of carbon blocks set below the hearth and there are no water jackets of any kind. One of the advantages claimed is steadiness of load on the power line when cold scrap is used. This type has all the disadvantages

of the Girod furnace. There are no furnaces of this design in operation in this country.

The Nathuseus furnace is similar to the Girod, but combines heating from above by arcs with resistance heating from below in the steel bath, the purpose of which is to decrease local heating by the arcs. There are no furnaces of this type in this country.

The Snyder furnace is a smaller one of the Girod type and is used principally by small steel foundries as a melting medium, no attempt being made to refine due to the size of the top electrode heating area which is limited. This furnace is adaptable only for very small units.

Heroult Furnace

The Heroult furnace is built similar to the hearth portion of an open-hearth. It is encased in a shell and is covered with a removable roof of silica brick. All the electrodes are above the metal and the current travels from the electrode to the metal, through the metal to the next electrode and so on out through the electrodes which are in multiples, the number of these being controlled by the size of the furnace. The electrodes are made of amorphous carbon and are threaded for continuous feeding. The three electrodes enter vertically through openings in the roof and project down to within one or two inches of the bath when molten. A steel, overhead structure supports the electrodes and they are kept in alignment by vertical guides. The electrodes are regulated by invention of R. Thury, of Switzerland, and was first applied by the late Dr. Heroult to his first steel furnace in 1901. It has no limitations in the handling of power and in no way interrupts the free play of the controlling mechanism. By its use great variations of power can be obtained automatically. As the wear on the roof is exceedingly severe, a spare roof is kept on hand for immediate installation. When the steel is ready for tapping, the entire furnace, together with the electrode supports, is tilted the same as an ordinary tilting furnace and the mechanical arrangement is such that the furnace rights itself by its own weight. The advantages claimed for the Heroult furnace are low cost of melting, automatic electrode

regulation and low upkeep cost. The disadvantages claimed are high peak load and variation due to arc jumping when working with cold scrap. This has been overcome to a great extent by judicious charging of scrap.

Induction Furnaces

The various types of induction furnaces are based on the same principle. In this type the use of electrodes is eliminated entirely, as well as the contamination of the steel by pieces of carbon breaking off the electrodes. The absence of carbon electrodes is made possible by causing the molten metal in a continuous circuit to carry the energy, which is applied to it by magnetic induction.

In other words an induction furnace is a step-down transformer with a short-circuited secondary consisting of a single turn of the molten metal. It is obvious that the molten metal must be confined in a channel surrounding the core of the transformer, which also is wound with a suitable number of turns to correspond with the alternating voltage applied. As counterbalancing the obvious advantages, this furnace has losses and disadvantages which have restricted its general use. It is subject to magnetic and electrical losses due to hysteresis in the iron core, heat losses in the primary circuit and magnetic leakage. Furthermore, there is a large heat radiating surface by reason of the long channel which must be employed for a given quantity of metal. Advantages claimed for this furnace are absence of electrodes, heat generation in the steel itself, high efficiency and low power consumption. The disadvantages are the necessity for retaining molten metal in the bath at all times, high upkeep and low production. According to *Reactions* it was necessary to use thermit to start an induction furnace in New Jersey.

Electro-Bessemer Furnace

The electro-Bessemer furnace was devised with a view of combining the Bessemer process with the electric furnace in the same vessel. It consists of a closed vessel having an opening in one side for charging and withdrawing slags. One end of the furnace is fitted with tuyeres for blowing and at the

other end electrodes are arranged to enter through the furnace wall, a tapping hole being provided at this end. The process is as follows: The furnace is charged with molten metal direct from the cupola and as the vessel is raised to a vertical position, the blast comes into action automatically and the blowing proceeds as in the ordinary converter, except that the flame is playing on the other *electrical* end. Upon the completion of the blow the furnace is tilted, the metal being transferred to the end containing the electrodes. Current is turned on and the refining operation is continued to the desired limit. This furnace, to the writer's knowledge has not been successfully operated and the metallurgist need not wonder why.

It has been demonstrated successfully in Germany that with a good scrap market in the vicinity of a steel foundry, the acid electric furnace can be worked more economically than the basic to produce steel for castings having an analysis approximately the same as that common to acid open-hearth practice. More attention should be given to acid electric furnace melting in this country, as we have a tremendous low phosphorus, low sulphur scrap supply. We must remember the buyer of steel castings will not pay 2 cents per pound more for steel, because it is 0.03 per cent lower in phosphorus and sulphur than the general run of acid castings. Electric steel may be summed up as being first in quality and easiest to control.

The process is very flexible and I regard it as the coming process for all steel casting.

At the present time the electric furnace offers a virgin field of undeveloped possibilities.

Discussion of General Melting Characteristics of Acid Steel

THE CHAIRMAN, MR. R. A. BULL:—Mr. Blackwood has covered a great many interesting points in his paper, not all of which he has mentioned in his abstract. I think there are a good many points productive of further discussion and would be glad to hear from you. Mr. Blackwood is somewhat original in some of his ideas and I believe he will welcome a little argument.

MR. F. T. SNYDER:—As Mr. Blackwood took my name in vain in his paper, I want to say something. He speaks of our furnace as being adapted to small tonnages only. The largest type of open-hearth furnace today is outputting about 200 tons of steel in 24 hours. We have running a furnace which is 5 feet in internal diameter. By increasing that diameter to 6 feet, it will give an output of 190 tons of steel in 24 hours. I feel that I should mention this as an argument against Mr. Blackwood's statement.

MR. A. F. S. BLACKWOOD:—I cannot see where Mr. Snyder's furnace can melt that amount of steel. In the first place, it has a single electrode and has a certain radiation of heat. One electrode will only radiate a certain amount of heat under a certain condition. If you increase your voltage you may get a pretty good working furnace for one or two months, but I should be very much surprised if you can melt 5 tons of steel in one operation.

MR. F. T. SNYDER:—I think the only excuse I have got for talking in a shop way is perhaps that the information will really be of service to the foundrymen. The heat naturally does not come from the electrode, but from the arc and the amount of heat you can get from the arc depends on the size of the arc. Our furnaces are unique in the fact that the arc is very long, 10, 12 or 14 inches long, so that it has a great deal of surface and gives what we call a flame arc

which is soft and comparatively cool and makes it possible to transmit a great deal of energy. We are now putting 800 kilowatts through an arc 8 inches long and 2 inches in diameter, and there is no difficulty in absorbing the heat to get a greater output. You simply have to put a greater amount of power in and that can be put in to greater advantage in a single arc than in a double arc, due to the arc being large and of low temperature. They are other advantages of that type of arc. You reduce the consumption of electrodes per ton, and get the refractory cost down to in the neighborhood of 15 to 16 cents a ton of steel.

MR. A. F. S. BLACKWOOD:—I always understood that a high arc burns the roof very fast. Can you explain that?

MR. F. T. SNYDER:—The point has been raised that a big electrode shatters the roof. It seems to me the point missed altogether is that the arc temperature is not a single temperature. There are a great many different kinds of arcs, hot arcs and cold ones. The ordinary type of mercury arc lamp is so cold that you can put your hand on it. We have there a very low temperature arc. On the other hand in the arc light as you see it in the street, you have a carbon arc which is a very high temperature arc. On the electric furnace we have a silicon oxide arc and in our particular type of furnace we have developed the voltage and current so as to get a very low temperature arc with very large surface which naturally does not eat up the roof. The builders of the Snyder furnaces are willing to contract to build a single furnace of the same design and type as those now in operation, with a guaranteed total output of 190 tons of melted metal in 24 hours. There is today in operation at the foundry of the Otis Elevator Co., Buffalo, N. Y., a furnace able to produce 30 tons of melted metal in 24 hours. This furnace is putting steel into the ladle at a cost lower than open-hearth for an equal tonnage. The reason the Snyder electric steel furnace can be built in such large sizes is due to large arc used. This arc is so large that it forms a considerable sized flame, and it is the heat from this flame that uniformly heats the entire

surface of the bath of steel. In the Snyder furnace the bulk of the heat is delivered by radiation from the arc flame in place of by contact with small arcs, as in the other electric furnaces mentioned.

MR. W. L. MORRISON:—I would like to say one thing about these tuyeres. Mr. Blackwood says he has run 500 or 600 heats off of a set of tuyeres. I don't doubt that, but he surfaces them up, levels them on the back side, and builds practically new tuyeres every day. The tuyeres are built up so that they are long enough every day to run 64 blows in a week, whereas I didn't touch the tuyeres at all. The tuyeres were left till the end of the week.

MR. A. F. S. BLACKWOOD:—I consider it bad practice for a man to run 64 blows and never look at his tuyeres. All we have in the converter is tuyeres and we must see that they are right.

MR. W. L. MORRISON:—I didn't fail to look at the tuyeres. I looked at them, but the tuyeres were in such a condition that they didn't need attention and with the ganister lining you can get longer runs without repairing the tuyeres.

MR. S. STONEHAM:—I would like to ask the speaker what he did with the tuyeres after the 64th blow? He said he looked at the tuyeres every day but didn't touch them.

MR. W. L. MORRISON:—I removed them, of course, and started in the next week with a new set of tuyeres.

MR. A. F. S. BLACKWOOD:—We all know that we ought to have our lining of the same dimensions all the time the metal is inside. The blow has to be in a certain position to the tuyeres and after you take 20 or 30 blows off, the tuyeres must be shorter than before and there must be more metal in there. It takes just so much oxygen to combine with so much silicon to make SiO_2 and if you have more, you are going to have cold steel. Therefore I claim that it is necessary for your tuyeres to be the same every day.

Defects in Steel Castings and the Remedies for Them

By John Howe Hall, New York City.

The steel foundryman has to guard against imperfections in his castings of several distinct types, which for convenience may be divided into the following classes:

1. Pipes and other cavities due to contraction of the steel and formed chiefly during solidification.

2. Stresses set up and cracks formed by contraction of the steel in the solid or semi-solid state.

3. Internal blow-holes.

4. Surface blow-holes, sand-holes and other exterior imperfections.

Obviously, these imperfections must be prevented with the minimum loss of metal scrapped in the form of sink heads, gates and runners. This paper is an attempt to set forth the principles that govern the methods commonly used to prevent the occurrence of these imperfections. Our metallurgists have not, up to the present time, studied these general principles so thoroughly as they have the proper methods to pursue in making steel of good quality; or, if they have done so they have not often published the results of their cogitations. There is, perhaps, a feeling among some of them that their proper sphere is the production of good fluid steel in the ladle and the heat treatment of the solidified castings, and that the production of sound castings is a simple matter that the molders should be able to attend to themselves. Since the phenomenon of the contraction of steel in solidifying and cooling is far from simple, it is plain on a little reflection that the expert should pay attention to the molding and pouring, equally with the steel making and annealing. Indeed, the metallurgist who realizes, for instance, that some blow-holes are due to gassy steel and some to bad molding practice, and who is being held responsible by his superiors for all spongy castings on the

score of "poor steel," is soon forced in self-defense to give his most careful attention to the subject.

Pipes and Solidification Cavities.

These may be defined as cavities due to contraction of the steel and formed chiefly during solidification. It has not yet been definitely established whether steel actually expands or contracts at the moment of solidification. In a most careful exposition of the subject of piping in steel ingots*, however, Professor Howe has shown that whether the steel contracts or expands in solidifying, the inevitable result of the comparatively rapid cooling of a mass of steel like an ingot is that the liquid metal in the interior fails to fill the first-frozen shell by progressively increasing amounts, and so sinks more and more as the ingot-walls thicken, producing the well-known "pipe."

His explanation of this is as follows: "Consider the shell of steel frozen around the liquid ingot as consisting of two parts, the outer layer and the inner layers. The steel of all the layers tends to contract as it cools. The outer layer cools much faster than the inner layers, until it has reached comparatively low temperatures. Hence this outer layer tends to contract more rapidly than the layers within it. The layers, being actually parts of a continuous mass, cannot slide upon each other in contracting. Hence, the contraction of the fast-cooling outer layer is in part prevented by the resistance to its motion of the slower-cooling inner layers, and the outside material is virtually expanded because the stresses set up in it by its contraction against the resistance of the inner layers exceed the elastic limit and cause the steel to yield." Thus in the first period of cooling, which Professor Howe calls the pipeless period, the outer walls of the ingot are held out to a length which they should not properly possess, and would not, were their contraction unimpeded.

As the outer layers become colder and colder the heat is abstracted from them at a diminishing rate, and finally a point

*"Piping and Segregation in Steel Ingots," Transactions of the American Institute of Mining Engineers, 1907, page 3. See also Howe and Stoughton, same volume, page 109.

is reached when the inner layers are cooling more rapidly than the outer. The second, or pipe-forming, period then begins. During this period, the inner layers are cooling and contracting faster than the outer, to which they are integrally attached. Hence the contraction of the inner layers toward the outer increases the size of the interior cavity occupied by the molten metal, and the latter fails to fill the cavity.* Therefore, its surface sinks down more and more as the freezing walls of the ingot thicken and the size of the interior cavity increases. The result is the familiar pear-shaped cavity, with vertical ribs or corrugations. Below this smooth-sided portion of the pipe is a narrow, steep-sided and rough-sided portion resulting from the tearing apart of the solid but soft metal below the part of the pipe formed during actual solidification, this tearing apart being due to the continued outward contraction of the inner layers of the ingot as the cooling of the solid metal progresses.

Factors Affecting Depth of the Pipe.

As set forth in Professor Howe's article, the depth of the pipe is lessened:

(1) By casting in wide ingots.
(2) By casting in sand-lined molds (particularly if the molds are pre-heated).
(3) By pouring from the top instead of from the bottom.
(4) By pouring slowly.
(5) By casting large end up.
(6) By casting with a sink head at the top.
(7) By permitting blow-holes to form.
(8) By liquid compression in presses.

(1) The use of wide ingots so increases the total amount of heat to be abstracted from the steel and carried away by the mold walls, as to decrease greatly the proportion which the length of the first period of cooling, the pipeless period, bears to that of the second or pipe-forming period. Hence the relative amount of the virtual expansion of the outer layers

*Professor Howe gives a most careful exposition of the truth of this postulate.

is lessened, and the tendency to deep piping diminished. Thus Professor Howe explains the formation of the very deep pipe found in narrow ingots.

(2) The use of sand lined molds decreased the rate at which heat is abstracted from the exterior layers when they are first frozen. If the mold is pre-heated, this is even more pronounced. Hence the amount by which the exterior layers outstrip the inner layers in cooling is decreased, the virtual expansion of the outer layers diminished, and the tendency to deep piping lessened.

These two methods, the use of wide ingots and the use of sand-lined molds, act by diminishing the tendency to deep piping.

(3 to 6) Methods 3 to 6 are pipe-closing in their tendency, and act by favoring what Professor Howe has called "down-sagging," that is the sliding of the plastic, semi-solid metal upon the interior of the pipe, down its walls. This sliding downward of the metal upon the inside of the pipe as the walls of the ingot thicken will manifestly tend to fill the bottom of the deepening pipe, and hence to limit the depth that it will finally attain. In order that this down-sliding should be a maximum, the metal that is to slide manifestly must be in a position to do the most sliding after the pipe begins to form. Hence, it must do most of its solidifying after the pipe has begun to open. It is an obvious inference that the upper metal, that is to slide downward, must freeze after the metal below. Therefore, the top of the ingot should freeze last. Pouring from the top has this tendency because it fills the top last with hot metal from the ladle, which is run in above the metal already in the molds, whose cooling has already begun. Pouring slowly allows the cooling of the lower portion of the ingot to proceed very far before the hot top metal is poured. Pouring large end up, by increasing the amount of heat to be abstracted from the top of the ingot and decreasing that to be taken from the bottom, has the same effect of keeping the top hot and favoring the maximum down-sliding. A sink-head, especially if cast in sand so that it cools more slowly than the rest of the ingot, of course has the same effect.

(7 and 8) Permitting blow-holes to form decreases the depth of the pipe by forcing the interior metal to occupy more space than it would if sound, and so to expand and rise into the pipe. Fluid compression, properly applied, also forces the interior metal into the pipe. The latter method is of no interest to the foundryman, for obvious reasons; and as blow-holes are highly undesirable in the average steel casting, it does not help the foundryman much to know that they will aid him to decrease the size of the shrinkage cavities in his castings.

Applying These Methods to Castings

In applying to castings the methods of decreasing depth of pipe above outlined, we see at once that the first two methods, the use of wide ingots and of sand molds, are not directly applicable; the first because the thickness of our sections is fixed by the design of the casting to be made, the second because we cast in sand anyway. There are, however, certain very practical applications of these two methods. The first is perhaps more closely allied to No. 5, casting large end up, and is that as far as possible we should try so to place our casting in the mold that heavy sections are above light ones. Thus we ensure that the upper portions will tend to freeze last, and so feed the contraction of the lighter sections below to the greatest possible extent. From Professor Howe's explanation of the causes of piping, we see that the light portions of a casting are, *per se,* more prone to the formation of pipe and shrinkage cavities than the heavy sections. In a great many cases this tendency is masked by the fact that these light portions are integrally united to heavy parts of the casting, which freeze last and contribute their interior metal to fill the cavities forming in the light portions. The drain thus brought upon the heavy sections, added to their own tendency to pipe, results in their being more often found hollow than the light sections, and so we say the heavy sections are most prone to contain pipes and shrinkage cavities.

In cases where the casting is poured with the light sections above the heavy ones, we frequently find the former

badly affected, a great part of the opening being in the form of rough-sided cavity. We say we are dealing with a shrink-hole. In many cases, no doubt, this is the lower portion of the pipe, drawn open after the metal has frozen, and much exceeding the true pipe in size. Had there been a means of feeding the section, the cavity would have been filled.

Chills

The most obvious conclusion to be derived from the fact that ingots cast in sand molds do not pipe as badly as those cast in iron molds (Method 2) is that castings in general do not form pipes as large or as deep as those in ingots of equivalent section. Nevertheless, the piping of castings is often serious enough to ruin them unless it is prevented by proper feeding. The use we can make of Method 2 is very much the same as in the case of pouring ingots, which are sometimes cast in an iron mold with a sand-lined top. Similarly, we can cause certain parts of a casting to cool ahead of the other portions by making the walls of the mold of metal, at the points where we wish the cooling to be rapid. By the use of chills we can cause certain portions, generally the lower portions, of the casting to freeze before the upper parts, and thus assist the top to remain molten after the bottom has frozen by hastening the cooling of the latter. In a way, this is the equivalent of Method 6, the use of sink-head kept hot longer than the body of the ingot in order that its interior metal may slide down and fill the pipe.

Thus, a chill has in many cases a function allied to that of a sink-head, that is, its primary object may be to assist the feeding of the lower portions of the casting by the upper. This may be called the first function of chills, and is a most important one. I shall return to this subject a little later, after considering Methods 3, 4, 5 and 6.

Very Slow Solidification

There is still a further practical application of Professor Howe's Method 2 of decreasing the depth of the pipe, which is utilized in ingot practice. This is, to strip the ingots while their interior is still molten and charge them on end in the

soaking pits, where their final solidification takes place slowly. The effect of this is that the metal solidifying upon the walls of the ingot has the greatest possible opportunity to slide down and fill the lower portion of the pipe, so that ingots handled in this manner do not pipe as deeply as those that are allowed to solidify completely in the molds.

In some cases it might be possible to accomplish a similar result by shaking out a casting before it is entirely solidified and charging it into a hot furnace where it is kept on end and allowed to complete its solidification slowly. By this method of handling, the metal in the sink heads would slide down to such an extent that the total amount of metal fed by a head of given size would be increased, so that a smaller head would be sufficient to do the work. The difficulty of so handling a casting, however, would in most cases prevent the use of this method. A modification of it, however, might be used for very large castings. Thus the heads and possibly a portion of the heavy upper parts of such a casting might be kept hot by removing the mold from around them and surrounding them with a brick-lined stove that could be put in position quickly and kept hot by means of oil burners or a coal fire. This method, indeed, is used to a certain extent when we heat the top of a sink-head with oil burners or a charcoal fire. Another way of accomplishing the same result is to use thermit in the heads in order to warm them up by the heat of the thermit reaction.

Position of Gates and Sink Heads

Theoretically, the best way to fill a casting is from the top (Method 3), straight down the sink-head, filling the top slowly (Method 4). The heavier sections should be above the lighter, that the top may freeze last and feed the bottom (Method 5); in some cases the bottom sections should be poured in chills (Method 2, reversed); and there should be extra metal above the casting proper in the form of a sink-head (Method 6), to feed the contraction of the upper portions. By such a method of pouring we should use all the available means for obtaining sound ingots. The stream of

metal falling into the mold, however, would necessarily cut the sand so badly as to ruin the casting; or if cores intervened, they would be destroyed. Hence, we are compelled in the majority of cases to take the metal down a runner exterior to the casting itself, and into the casting by means of gates at or near the bottom. By dishing out the bottom of the runner and "nailing" the part so dished, we provide a basin whence the metal can enter the mold quietly and without cutting the sand, or spattering in such a way as to lead to surface imperfections.

Our molds, therefore, are commonly filled from the bottom, so that the metal which finally forms the top of the casting is that which first entered the mold and is the coldest. This is in direct violation of principle 3, but in most cases it is the only way to do the pouring. True, it is quite common to stop pouring through the gate when the metal reaches the sink-heads, and pour the latter from the top, and this practice is theoretically correct, (Methods 3 and 4). But in some cases this is not sufficient, as the cooling of the upper part of a tall casting may outrun that of the bottom portions, poured last, to such an extent as to make it impossible for the feeding of the sink-heads to be effective. We may easily imagine a case where the top metal is so cold when pouring stops that it freezes completely, forming only its own small pipe. The sink-head will feed this; but the later-freezing lower portions will form their own contradiction-cavity, which is completely bridged off from the sink-head by the frozen upper portions.

Modification of Method 3—Top Pouring by Sections

This condition may often be met by arranging a series of gates at several levels, so that as soon as the mold and runner are filled up to the level of gate two (counting from the bottom) the metal will enter the mold through this gate and run in over that already in the mold. When the steel reaches the level of gate three, the process will be repeated. In this way we attain the advantages of top pouring, at least in part, by pouring in a series of sections; each section as it were acting as sink-head for the part below, and the sink-head proper

feeding the last section poured. This is the first advantage of the use of gates at several levels. We shall again refer to the subject and mention the second advantage, in discussing the question of the size of gates and runners.

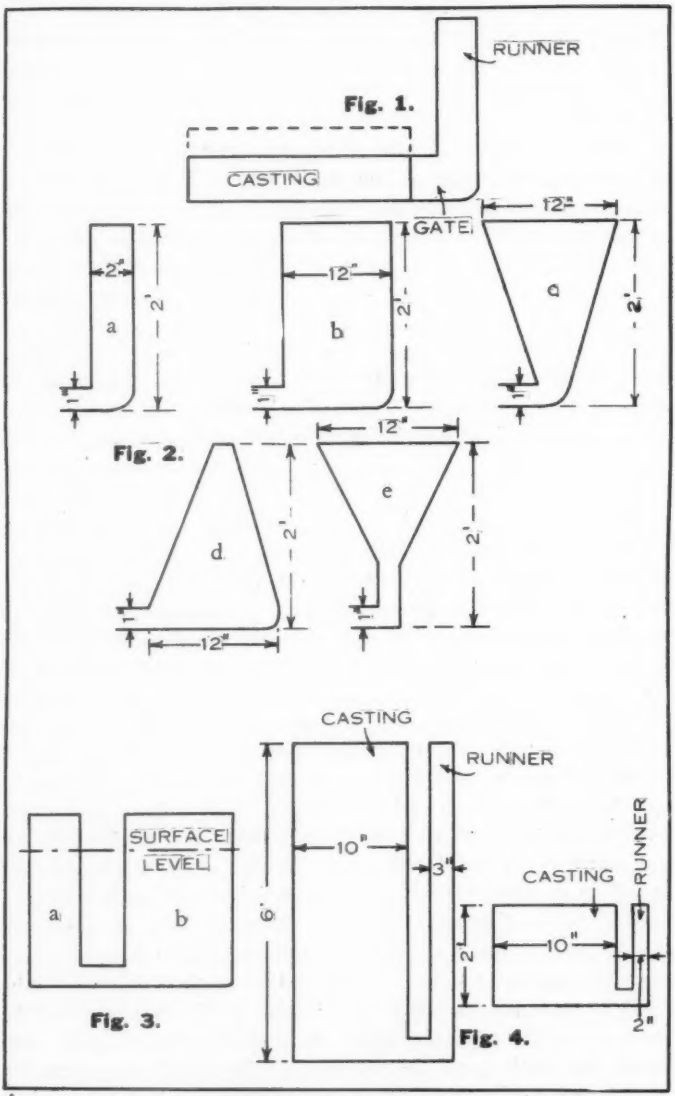
There are certain disadvantages of this method, which may in some cases prevent its use. The first is that any loose sand from the mold, which ordinarily floats upon the steel as the mold is filled, and hence is carried upward to the sink-head, where it can do no harm, may be trapped in the casting when the metal begins to flow in through the upper gates. The second is the danger of filling the runner too quickly, so that metal will flow through the second gate before the metal in the casting has reached that level, and cut out the mold as it flows down its walls. These disadvantages, however, are in many cases neither insurmountable nor prohibitive.

Action of Chills in Reinforcing that of Sink-Heads

To return to the subject of chills from the standpoint of their first function, that of decreasing the size of shrinkage cavities. The laws laid down by Professor Howe show us that if we pour the bottom third of a casting, for instance, in heavy chills, we give to that third of the casting the maximum tendency to pipe; since piping is the more pronounced the more the rate of cooling of the outer layers outstrips that of the inner during the first period of cooling, and heavy chills favor this condition. We thus cause the bottom third of the casting to pipe deeply, and since its cooling as a whole will be rapid, to pipe early. If this early and deep piping can be made to begin while metal is still being run in through the gate, that fresh metal will partly fill the cavity while pouring is still in progress; thus part, at least, of the object sought, the feeding of the casting, takes place during pouring.

In certain cases where the vertical height of the casting is small, compared to that of the runner, and no separate sink-head is used, the runner itself may be considered as the sink-head. In this case, the action of properly placed chills may cause the feeding of the casting by the metal being run in to proceed so far that the metal in the runner will complete

XUM



FIGS. 1-4—ILLUSTRATIONS OF LAWS OF FLUID PRESSURE

the work after pouring ceases and make a perfectly sound casting. The gates and chills, of course, must be so arranged that the later-poured metal may flow in over that already in the mold; hence the neighborhood of the gate must not be chilled. It is also essential that the first metal be run in rapidly, and the pouring completed slowly.

In some cases the runner will feed such a casting, even without the assistance of chills; in others, the chills are necessary to produce a sound casting; and in any case, the casting must be low compared to the runner, so that there is no considerable portion of it above the gate. In theory, at least, such a casting, in order to be made sound by the metal in the runner alone, should be provided with a gate from top to bottom on one side, so that the feeding of all levels of the casting is by metal running in from above. Actually, of course, the gate need not be quite the full height of the casting, as shown by the dotted lines in Fig. 1.

Even when a sink-head is used in addition to the chills, so that we do not depend upon the runner to feed the casting after pouring ceases, this action of the chills is valuable, since it effects the feeding of the lower portions of the casting by the metal being run in through the gate. To take advantage of it to the full, the sink-head should be poured separately and from the top. Otherwise, we shall fill the head with the first-poured metal that has been cooled by the chills, and the head will tend to cool before the casting.

We spoke above of the fact that a high casting, poured through a single gate at the bottom, may freeze at or near the top to such an extent as to bridge off the sink-head from the lower part of the casting, with the result that the piece will be unsound below. This, we saw, can be guarded against by the use of gates at several levels. The same end may be attained in certain cases by the use of chills on the lower parts of the casting, which so hasten the cooling of those portions as to cause them to freeze ahead of the upper parts. Manifestly, however, it will be advisable in many cases to use both these methods, since their effects are cumulative. Indeed, if the metal is all poured through a gate at the bottom, the

effectiveness of the chills will inevitably be reduced by the chilling of the metal that first enters the mold and ultimately forms the top of the casting, which has to flow over the chills to a certain extent and consequently is not as hot as it should be when it reaches its final position. When, on the other hand, the metal enters at several levels successively the bottom of the casting is filled by the first metal entering the mold, and hot metal is run in on top of it through the upper gates; and in addition, the freezing of the lower portions is hastened by the chills. We thus get the full benefit of both the chills and the pouring in layers, so that as just stated their effects are cumulative.

Proportioning Gates and Runners—Laws of Fluid Pressure

In the proportioning both of gates and runners, and of sinkheads and necks, the laws of fluid pressure are of great importance. Misconception of these laws frequently leads to the adoption of means of feeding and pouring castings that result in great waste of metal scrapped as sprues, without in any way increasing the tendency to make the casting sound.

Briefly stated, this law is that in any body of liquid, be it water or fluid steel, the pressure per square inch at any given point is dependent only upon the depth of that point below the surface; and that the pressure at this point is equal in all direction. Thus, the several runners shown in Fig. 2 all exert the same pressure on the 1-inch gate; there is no more tendency to "force the metal into the mold" in the case of the large runners *b*, *c* and *e*, than in that of the small one *a*. That the pressure in each case is the same we know, because if we join, for instance, *a* and *b*, as shown in Fig. 3, and pour both full of liquid, the level of the surface of the liquid will be the same in both. Now if there were a greater tendency in *b* to "force the metal through the gate", obviously the metal would rise in *a*.

A second point of importance in this connection is that when the metal is at a higher level in *a*, for instance, than in *b*, it tends to flow into *b*; and the effective pressure on the metal in the gate is proportional to the difference between the level in

a and that in *b*. As *b* fills up, this effective pressure decreases, and becomes zero when the metal is at the same level in the two sides. If *b* is fuller than *a* the same condition exists, but the direction of flow will be reversed. The fact that *b* is of greater cross-section than *a*, however, does not make the effective pressure at the gate any greater when the level of the metal in *b* is, for instance, 6 inches above that of the metal in *a*, than it is when the level in *a* is 6 inches higher than that in *b*.

This brings us to the consideration of the proper relative proportion of the sizes of gate and runner. The latter should obviously be large enough to carry the metal into the mold as fast as it is needed; therefore, it must be able to carry away the proper sized stream of metal as fast as it is poured from the ladle. Now if this is the case, and the gate or gates are of smaller cross-section than the runner, the latter will fill up with metal rapidly. The difference in level between the metal in the casting and that in the runner will then increase, putting more pressure upon the metal in the gate and increasing the velocity of its flow. This will be disadvantageous, first, because it will tend to cut out the sand of the mold, and second, because it will diminish the rate at which the casting as a whole is filled, and especially the rate at which the last metal enters the mold. For while the velocity of the entering stream will be increased as the runner fills up, so that at first the quantity of metal entering the mold will be maintained at nearly its proper amount; yet when the runner is full, the velocity cannot be further increased, and will as a matter of fact fall, as the casting fills and the difference in level between the metal in the casting and that in the runner decreases. As a result, the metal toward the last will enter the casting very slowly, and the gate and lower part of the runner may even freeze. We see, therefore, that the area of the gates should equal that of the runner.

To put this somewhat differently, and perhaps more exactly, the average rate of flow is determined by the size of the gate, and the average difference of level between the metal in runner and casting during the pouring of the mold. If the gate is so much smaller than the runner that the latter is full practically

from the time pouring begins, the flow at first will be proportional to the height of the runner, and at the last will be zero,—the average flow being proportional, then, to half the height of the runner. If the gate and the runner are of the same size and capable of carrying the metal as fast as it is run in, the difference in level between the metal in the casting and that in the gate will be practically uniform throughout; since this level will be that which suffices to overcome the friction of the flowing metal against the sides of casting, gate and runner. As the metal grows cold in the casting and its fluidity decreases, this friction will increase, so that the difference in level will gradually increase. Thus the flow will be fairly uniform throughout, and a considerable decrease in the rate of pouring toward the last will be voluntary (as by decreasing the rate of pouring), rather than involuntary.

Thus the cross-section of the gate or gates should be equal to that of the runner,—in most cases there will be no object in making it greater. Should there be a number of gates, however, whose total cross-section is equal to that of the runner, they may be individually so small as to be in danger of freezing. In this event, their total cross-section may be made greater than that of the runner.

Second Advantage of the Use of Gates at Several Levels

In filling a high casting through a single gate at the bottom, the metal that first enters the mold often becomes cold and semi-solid, and by its friction against the side of the mold greatly retards the rate at which the metal rises in the mold. The more slowly the mold is filled, the more pronounced this retardation. Hence, we must use a gate and runner of large cross-section; for if they are small the mold will be filled so slowly that the metal first poured will become very much chilled before it has reached its final resting place, this chilling will greatly decrease the rate at which the metal flows into the casting, and the small gate and runner will be very apt to freeze shut. Hence, a high mold requires larger gates and runners than a low mold of the same cross-section, resulting in a greater loss of metal scrapped as sprues per pound of casting in

the case of the high mold. Take, for example, a single casting 10 inches in diameter and 6 feet high, requiring say a 3-inch runner, and three castings each 10 inches in diameter and 2 feet high, each requiring only a 2-inch runner, as shown in Fig. 4. We see that the weight of the three castings each 2 feet high equals that of the single casting 6 feet high. But the weight of the single 3-inch runner is greater than that of the three 2-inch runners in the ratio of 2.25 to 1. We scrap, therefore, about twice as much metal per pound of casting in making the single high casting as we do in casting the three low ones.

This brings us to the second advantage of the use of several gates at different levels in pouring a high casting, which was mentioned above. We see that if we use one runner and three gates 2 feet apart vertically, in pouring the single 6-foot casting, we can make the runner only 2 inches in diameter with perfect safety. For the lowest gate then is required to feed the metal only so fast that it will flow freely until the second gate is reached; whereupon, the pouring practically takes a fresh start on the second section of the casting, the metal flowing in through the second gate. We no longer have to lift the sluggish metal that first entered the mold, and the metal in the runner below the second gate may freeze and welcome,—the new gate will go on filling the casting. Thus in addition to improving the feeding by giving us partial top-pouring, the use of several gates leads to an actual saving of metal scrapped as sprues per pound of casting.

Multiple Pouring Not Analagous

It appears at first glance that a similar saving in weight of sprue scrap is effected by "multiple pouring" of small castings, by which a number of flasks are stacked on top of each other and poured through a common runner. A little examination of the subject shows us that it is not, at least as far as the diameter of runner that we can use is concerned. Reference to Fig. 5 will make this plain. Thus, if *a-a* be a series of small castings, poured through a common runner *b*, by means of gates *c*, we see that the pouring of the lowest

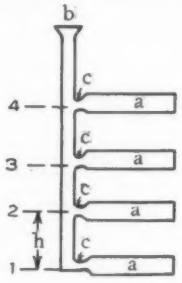


Fig. 5.

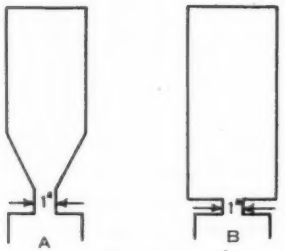
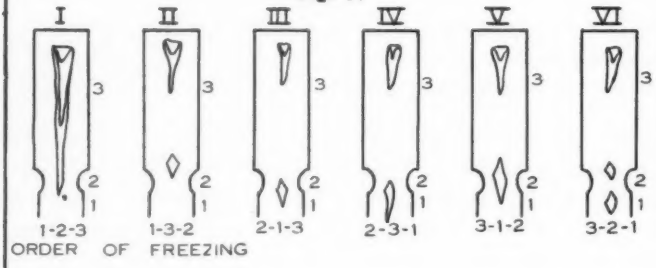


Fig. 6.

Fig. 7.



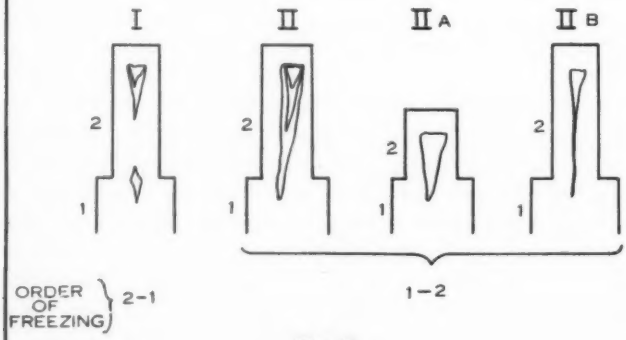


Fig. 8.

FIGS. 5-8—HOW SHRINK HEADS FREEZE

casting and of the lowest section of the runner, from level *1* up to level *2*, is in no way affected by the fact that there is additional runner extending above level *2*. The size of runner and gate necessary to pour the lowest casting is exactly the same as if this casting were being poured alone. The runner then fills up to level *2*, and the second casting is filled just as if there were no others either below or above it. No reduction in size of runner can be made on the score of reduced friction of cold metal rising in the mold, because there is never any question of pouring castings of greater height, but merely of a runner of greater height. Moreover, the height of the sections of runner appertaining to each casting is not necessarily any less than the height of the runner used in pouring the castings singly.

There are, however, two reasons why multiple pouring effects a certain saving in runner scrap. The first applies to the cases in which the runner acts as a sink-head and feeds the casting after pouring ceases. When the castings are poured singly, the runner has to be so thick and high that it will stay molten long enough to provide the necessary metal to feed the casting. With a common runner for several castings at different levels, the metal in each section of the runner helps to feed the section below, both during and after the pouring of the lower section, and thus the length of runner per casting (and possibly the diameter) may be somewhat reduced.

The second source of saving is in the cup-shaped tops of the runners. If we use but one runner for six or eight castings instead of six or eight runners, each with its small cup at the top, we save just so much metal. This saving, however, is not necessarily considerable, as the use of a cup-shaped top on the runners is not always essential. There will also be a certain saving in spatterings, since we shall fill up to the top of but one runner for say six or eight flasks, instead of to the top of six or eight runners. It is by no means necessary to run metal over the top of the flasks in pouring, however, and a good gang will not lose much metal by slopping, so that this saving will not amount to much with careful workmen. Thus the chief advantage of multiple pouring

is not so much the saving in sprue scrap, as the economies that it allows in floor space, top weights in the case of snap flasks, and pouring time.

Sink-Heads

From what has already been said it is apparent that in the designing and locating of sink-heads, it is important so to place the casting in the mold and so to distribute the chills that the maximum amount of feeding will be done (1) during pouring, by the hot metal being run into the mold; (2) by the heavy sections of the casting which feed the light sections placed below, and (3) by the heads during the time when they are actually being filled (preferably from the top, so that they will be poured with fresh hot metal). In many cases it is impossible to take advantage of all of these methods. By careful arrangement, however, it is generally possible to utilize one or more of them, so that the heads have the least possible amount of feeding to do after the pouring is stopped.

Thus in designing and placing heads we first consider how far we can take the work of feeding away from them and put it somewhere else. Then we consider the size of the head to be used, in view of the size of the section to be fed, and especially in view of the size of the neck through which the head is to feed.

Laws of Fluid Pressure Again

In a great many cases, the thickness of the neck is fixed by that of the portion of the casting upon which the head is set. This being true, we are again confronted with the laws of fluid pressure which were mentioned in the discussion of gates and runners. That law teaches us that if the diameter of the neck is small, it is, from one point of view, quite useless to use a very wide head, because such a head exerts no more pressure upon the metal in the neck than would a head of equal height and of the same diameter as the neck. As far as exerting pressure upon the neck goes, only the height of the head is effective, and from this point of view the best head is one of diameter equal to that of the neck and of such a height that it shall contain enough metal to do all the feeding that will be needed.

But there is, of course, another side to this question, which is that a high and very narrow head would inevitably freeze to the center and cease to feed long before the cavity in the casting had been filled up, or to speak more accurately, before the cavity had ceased to form. We must, therefore, make the head of such a diameter that it shall not freeze to the center until after the necessity for its remaining molten ceases to exist,—in other words, the head must be at least as large, generally larger, than the section of casting it is to feed. It is quite useless, however, to provide a head of just the right proportions, if the neck freezes before the head has ceased to feed. Hence, the diameter of the neck must be great enough to prevent its freezing prematurely. The rate of cooling of a neck of a given diameter, moreover, is greatly influenced by its length and by the shape of the head. Thus a long neck, tapering upward to the full size of the head, *A*, Fig. 6, will cool much more rapidly than a short one of the same thickness, as shown at *B* in Fig. 6, because in the latter the short neck is kept hot by the closely adjacent mass of metal in the head and casting. The neck should, therefore, be made as short and be joined to the head as squarely as it is possible to mold them.

In many cases, of course, the sink-head is not necked-in at all, but is brought down to the casting at its full diameter. When the section to be fed is large enough to permit the use of such a head, the danger of premature freezing of the neck is of course eliminated.

We see, therefore, that when the diameter of the neck is fixed, as for instance by the width of the portion of the casting to which it is attached, the neck should be made as short as possible, and the head should be made with a square bottom and no wider than will suffice to keep its interior liquid and maintain the feed up to the moment when the neck freezes. All extra width beyond that necessary to accomplish this is so much plain waste of metal. The height of the head also should not be greater, for a given diameter of head and

neck, than is necessary to provide enough metal to feed the casting completely. The head that has done its work to perfection would be hollow just down to the neck. Frequently we see heads 8, 10 and even 12 inches in diameter and 18 inches or 2 feet high, with necks only 2 inches wide and 3 or 4 inches high. Manifestly, such heads have contained fluid metal and been capable of feeding the casting long after the neck, and even the casting itself, have solidified. The reservoir of liquid metal in the head is quite useless for the purpose for which it was provided, like a power dam with the flume to the turbine choked with mud,—the liquid we require to do our work is there, but it cannot flow to the place where we wish to use it.

The factors governing the proper size of head and neck for a given casting vary to such an extent that it is practically impossible to do more than estimate roughly, by the light of previous experience, how large they should be made, and then allow an ample margin for safety. Having made a casting with a given size of head, it may prove unsound, that is, it may show a pipe under the neck when the head has been knocked, or cut, from the casting. In that case, the best means of remedying the trouble has to be considered. Again, the casting below the neck may be sound. Generally, it is assumed in that case that the proportioning of the head has been correct—and so it has—as far as making a sound casting is concerned. Often, however, the margin of metal that has been provided is too great, so that the waste in sink-head scrap is excessive, and it will pay to consider how much the sink-head may be reduced in size without risk of making an unsound casting.

Theoretically, given a section of casting to be fed, a sink-head, and a neck connecting them, there are six different orders in which the three may freeze. These are represented diagrammatically in Fig. 7, numbered cases I to VI, with the order of freezing indicated and the shape and location that the cavities may be expected to assume sketched in. Of these, cases II, V and VI are of little interest, as they all involve the freezing of the head before that of the neck; a condition that will seldom be found to occur in practice, at least under ordinary circumstances.

Taking first case VI, we see that as the head, neck and casting successively freeze, the metal at the bottom of each being sustained by the still liquid metal beneath, each will form its own pipe; two of which will probably be more or less double-ended, as shown in the figure.

Similarly in case V, the head will form its own pipe, then the casting in freezing and piping will in all probability drain the neck, which will then freeze last and pipe at the top, forming a continuation of the pipe in the casting. Should the neck contain enough metal to feed the casting completely, this pipe of course would be only in the neck and not extend into the casting.

In case II, the casting would freeze first, and its pipe would be filled by the liquid metal above. Then the head would freeze and pipe, and lastly the neck would freeze and pipe.

Should the head freeze before the neck, as in cases V and VI, it would generally be found that the shrinkage of the casting that took place before the head froze would drain the neck, so that in either case there would probably be a more or less continuous pipe running through the neck and up into the head. The same would often be true in case II; so that a neck which has frozen later than the head will generally be hollow, the pipe going a little way into the head and in many cases extending into the casting. The remedy is a wider head, which in some cases may be made shorter; this being determined by the depth of the pipe in the upper part of the head.

In practice, cases I, III and IV will occur. Case I may involve a head, neck and casting all piped, as indicated by the deepest pipe shown in the sketch. In that event, there was obviously not enough metal in the head to feed the casting. The remedy depends upon the thickness of the shell of the frozen head and neck. If it is very thick, and if the pipe is but a very narrow hole, it is plain that if we secure more metal by increasing only the height of the head, the head and neck will freeze tight before this extra metal can reach the casting, and the situation will be that shown in case III. We need, therefore, a wider head and neck, and perhaps a

higher head also; since increased height gives greater pressure on the neck, and will force more metal through it when it is frozen nearly to the center.

If the walls are very thin, showing that the metal ran out much faster than it froze, increase of the height of the head, and a slight increase of the diameter, are called for. This case, however, may also indicate that if we had kept the ladle over the head a little longer and fed the shrinkage by slow pouring at the last, we should have come out all right with the head and neck we had.

On the other hand, if the casting and neck are sound, and the pipe in the head comparatively shallow, we have overdone the matter and wasted metal in the head. The latter may be reduced in height and probably also in diameter, until we find it is piped nearly to the bottom, as shown in the intermediate positions of the pipe in the sketch.

Cases III and IV are those in which the neck froze first, by far the commonest cause of piping in castings. In case III the final solidification of the casting occurred next after that of the neck, while in case IV the casting froze last. The chances are that the pipe will be deeper in case IV, because the beginning of solidification and pipe-forming in that case came longer after the neck closed, so that less feeding in the preliminary period of pipe-forming occurred. This pipe will run up into, but not through, the neck; since the upper part of the neck will have been fed by the head in both cases. There will in both cases be a pipe also in the upper part of the head.

The remedy is first and foremost a wider and if possible, shorter, neck, as it is not a question of not enough metal to feed, but of the feed channel being prematurely choked. The size and depth of the pipe in the upper part of the head will indicate further whether the head that was used contained too much or too little metal to complete the feeding had a neck of the proper size been provided.

Making Necks in Cores

It will be seen from the above discussion that to make the necks small, in order that the heads may be knocked off by means of a sledge hammer or drop ball or burned off at the

least expense, is dangerous practice because it may well lead to premature freezing of the neck. The result will be a pipe in the casting which will have to be plugged by means of the welder, the expense of the job often more than balancing the saving made in the cost of removing the head. Moreover, when the pipe is irregular and partly discontinuous the plugging often merely fills the top of the opening, like a cork in a bottle, and leaves the casting dangerously weak. Many a broken casting shows this defect in a striking manner. We may get our work accepted on a first order by indiscriminate plugging of holes, but if many of our castings break and show unsound places we will be pretty sure to find the customer has gone elsewhere for further orders.

By molding the neck in a special core it can be made very short, so that although considerably narrower in at least one dimension than the head, it will feed very efficiently. The core is so thin and the neck consequently so short, in this method of molding, that the mass of hot metal in the head and casting quickly brings the core to a high temperature and thus keeps the neck fluid. The result is a very perfect feed with a neck comparatively narrow in one dimension. Moreover, by properly shaping the opening in the core the neck may be so formed that it can safely be broken from the casting, even though quite heavy. Care has to be exercised, however, not to knock off too heavy a neck or one that is not shaped just right (caused in some cases by the partial disintegration of the core), as the heavy shock of the blow brought upon a casting already full of shrinkage stresses may crack the casting. This question is considered in more detail in the discussion of "hot" and "cold" cracks in castings.

When the head is the same size all the way down and no neck is used, there are but two orders in which freezing may occur—head first, or casting first. These cases, and the probable shape of the resulting pipe, are shown in Fig. 8.

When the head freezes first, it will form its own pipe; the casting will then freeze and the pipe formed in it will probably run up a little way into the head (case I). When the casting freezes first, it may be sound (case II). Then if the pipe

in the head reaches down only a little way, the head has been made too high and perhaps too wide. If the pipe in the head goes quite deep but does not reach the casting, the size of the head is theoretically correct. Should the pipe reach into the casting, it may be very wide, so that the walls of the head are thin (case II-A); this calls for a higher, and perhaps a somewhat wider head. If the walls of the head are very thick and the bottom part of the pipe a small hole, greater diameter of head is the obvious remedy (case II-B).

It is, of course, impossible to work out the proportions of heads with great exactness, or to draw hard and fast conclusions from the position and shape of the pipes in the castings and heads. But in most cases it will be found that piping can be corrected at the expense of a minimum of metal scrapped, or that the size of heads can be reduced, if we will set ourselves to reason out the proper design of heads and necks and make sure that we are putting the metal in them "where it will do the most good".

Heads Feed Most Efficiently Downward

It is plain that as the metal in a head flows, or tends to flow, by gravity, the action of the head is most efficient downward. The extent to which a head will feed an opening that extends chiefly in a horizontal direction is evidently not great. Hence, when a considerable extent of horizontal surface is to be provided with heads, especially if the vertical dimensions of the castings are small, a number of heads must be used and they must be placed so close together that their effects overlap. Such a casting will be more efficiently fed by a number of comparatively small heads placed close together than by a few heavy heads. At times such castings are provided with a few very thick, but comparatively short, heads, evidently with the idea that by providing great total weight of metal in the heads the casting can be fed throughout. Of course only the height of the heads is useful in providing the pressure required to force the metal to flow sidewise to the distant portions of an opening, so that the total weight of the heads has nothing to do with their effective-

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ness in feeding far in a horizontal direction. Short, thick heads, therefore, will feed only a limited area near their bases, frequently an area that cannot use all the metal they contain. Hence much of their extra weight is plain loss. Were this extra metal distributed over the casting in a number of small heads, on the other hand, it would nearly all be utilized in feeding the shrinkage immediately below each head.

In case only a few heads can be molded upon a casting of this sort, so that each head must feed horizontally to a considerable distance, we should remember that the amount of metal to be fed may not be great, but the pressure required to force

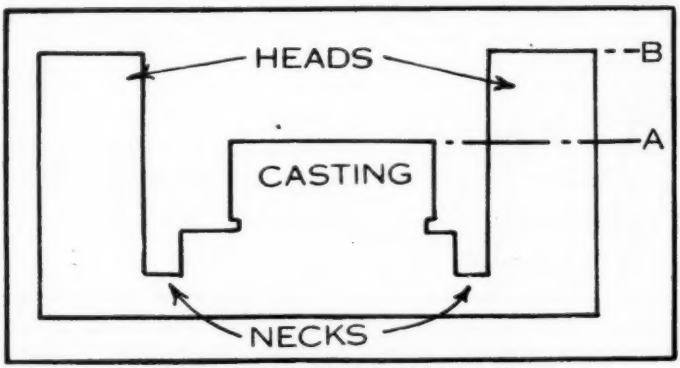


FIG. 9—IMPROPERLY PLACED HEADS

it to flow sidewise through an irregular opening may be considerable. In order to produce this pressure we need high heads. Increased height of heads to feed such a casting should in some cases be accompanied by decreased diameter, in order that there may not be too much waste of metal.

Trying to Make a Head Feed Sidewise and Upward

Another error sometimes committed is to use heavy heads with thick necks, attached to the sides of castings near the bottom. The heads are made very heavy, evidently with the idea that their total weight can be utilized in forcing the metal they contain up into the casting to feed the shrinkage

of the latter. If they fail to feed as expected, heavier, but seldom higher ones, are tried. Of course, to apply again our laws of fluid pressure, the effective pressure exerted upon the neck of the casting shown in Fig. 9 by the metal in the heads, is proportional only to the difference in level *A-B* between the metal in the head and that in the casting, so that after pouring is stopped only the portion *A-B* of the head is effective in producing pressure on the metal in the neck to make the latter flow. Increased diameter of head will not increase this pressure in the slightest—though by keeping the metal hot longer, it prolongs the period during which the

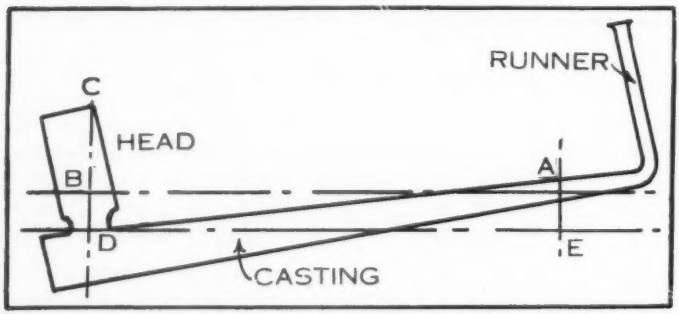


FIG. 10—HEAD PLACED AT LOWER END OF CASTING

pressure is exerted. Increased height of head, on the other hand, greatly increases the pressure.

Moreover, the heads, so attached, are laboring under the disadvantage that they do not feed their fluid metal directly downward into the top of the gradually deepening pipe, but have to do their work by bringing pressure to bear on the still liquid metal in the casting, by which that metal is made to flow upward and close the pipe, as it does when a solidifying ingot is compressed at the bottom. Working in this manner, the heads must fail to be effective as soon as the metal in the casting becomes too sticky to flow; and they cannot, however long they stay fluid, feed the portion of the pipe that forms after the metal of the casting has become solid. A head placed on top of the casting, on the other hand, continues to feed the pipe so long as the head and neck remain fluid. and it feeds

chiefly by direct flow, not by forcing the metal in the casting to move upward. Hence, it feeds efficiently at all stages of the formation of the pipe. Heads placed in the manner shown in Fig. 9 must inevitably be seriously inefficient, and in a great many cases might as well be omitted altogether as so attached.

Tipping Up Shallow Castings

Thin castings, especially long, narrow, shallow sections, are frequently tipped up at the gate end for pouring. The most obvious reason for doing this is that it assists the pouring by making the metal run down-hill, instead of along on the level, and so enables us to "run" a piece that we might not be able to fill in any other way. A further advantage of this method, however, is that it to some extent substitutes top pouring, and downward feeding by the heads along the length of the casting, for bottom pouring. The more we tip the casting up, the greater this advantage—indeed, whenever possible, we pour the thing "on end," so that when it is filled each section may feed that immediately below it, and a comparatively light head on top will suffice to give us a sound casting; while if we poured "on the flat," we might need several heads distributed along the casting.

In some cases such a casting can be made sound by the action of chills placed upon the lower end, without the use of sink heads. The metal running in through the gate does much of the feeding while the casting is being poured, and the metal in the runner suffices to feed the final shrinkage that takes place after pouring ceases. In case the effect of the chills will not suffice to make the casting sound, heads are necessary. These are frequently placed toward the lower end of the casting, especially if that end is the heavier. So located, the heads are not in a position to feed as efficiently as they should. In Fig. 10, for instance, we see that if the runner will suffice to feed the casting as far along as *A*, then the rest of the metal in the casting, from *A* to *D*, will tend to run downward toward *D*, and will exert a fluid pressure proportional to *A-E*, the difference in level between *A* and *D*. The portion of the head *B-D*, equal to *A-E*, is useful only to balance this pres-

sure, and only the portion of the head *B-C* exerts pressure upon the metal in the casting. Moreover, the conditions are much like those in the case of the side-attached head already discussed—we are trying to make the head close a pipe which will form in the upper portion of the casting, between *A* and *D*, by forcing the metal below to flow back against gravity and close a distant opening. A second head between *D* and *A* might or might not be so located as to be just over the place where the pipe tends to form, since the position of this pipe will vary from casting to casting, depending upon the temperature of the metal when poured, how fast it is poured, etc.

If for any reason it is essential to place the head on such a casting at the lower end, the head should be made as high as possible and should be poured separately with hot metal from a second ladle. If the head is filled with the metal run in through the gate, the metal in the head will be cold when pouring ceases, more especially if chills are used on the heavy portion to counteract to some extent the tendency to freeze at the top first; and as we have seen, the heads should, whenever possible, be filled with hot metal. If there is nothing to prevent it, the casting should be tipped up and gated at the heavy end, in order to conform to the rule that the top should be the last portion to freeze, and the head should be on the upper end, for the same reason. Chills, if used at all, should be on the lower end, but if the lower end is much the lighter they may not be needed.

Cracks in Castings

Cracks in castings are due primarily to the shrinkage of the steel in cooling from the temperature of solidification to that of their surroundings. The shrinkage of ordinary carbon steel amounts to about ¼-inch per foot, being somewhat less as the carbon approaches 0.90 per cent, and greater the lower the carbon. Could all parts of the casting cool at the same rate, shrinkage would not make trouble. But when a light portion cools ahead of a heavy one, the resultant shrinkage of the light section often brings a heavy pull on the heavy one when the latter is still hot and weak, resulting in the tearing

apart of the two at the weakest place—which is not necessarily the smallest section, but that which is weakest at the temperature existing when the stress is set up. Should the casting hold together, the later shrinkage of the heavy portion after the light part has become cold and rigid often sets up heavy compression stresses in the latter. Thus in the shrinkage stress test bar shown in Fig. 11, the light section cools first, the hotter heavy part yielding to the pressure. Then when the heavy portion begins to cool faster than the light part, the latter is compressed very strongly, so much so that if it is cut in two with a hack saw when cold, the moving together of the sides of the cut can be measured very easily. The magnitude of

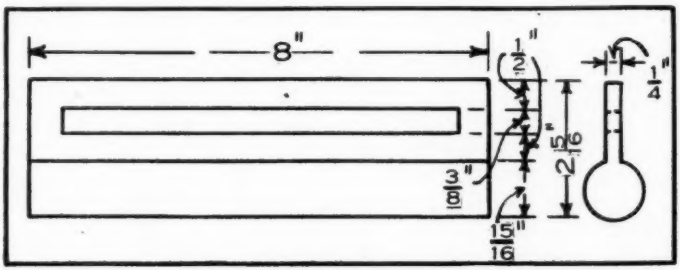


FIG. 11—SHRINKAGE TEST BAR

the stress set up is very great—so great that a blow with a hand hammer on the heavy part, and not a very heavy blow at that, suffices to snap the connecting leg between the light and heavy portions as if it were a pipe stem.

Cracks are favored by

1.—High sulphur in the steel, causing red-shortness.

2.—Low carbon, which gives the maximum shrinkage.

3.—Unevenness of sections, causing variations in the rate of cooling.

4.—Sharp corners in angles of castings, especially where a thick section joins a thin one.

5.—Use of tie-bars stronger than the casting.

6.—Resistance of mold and cores to shrinkage of casting.

We are obliged to make our castings either of a definitely specified carbon content, or of a low enough content to make the castings tough when annealed, and easily machined. We cannot, therefore, alter the carbon content to decrease the shrinkage. The sulphur content depends upon the raw material and the steel making process we use. Basic open-hearth steel can be kept quite low in sulphur, basic electric furnace steel even more so, without very great expense. Acid open-hearth, Bessemer and acid electric furnace steel frequently run rather high in sulphur, so that the foundryman who uses them is obliged to exercise more care in guarding against cracks than the user of basic steel. The effect of high sulphur content is to make the steel weak and brittle when hot (red-short), so that it more readily tears apart under shrinkage stresses.

The means by which the foundryman seeks to prevent cracks are

1.—The use of chills.

2.—The use of fillets.

3.—The use of brackets.

4.—The use of tie-bars weak enough to break before the casting does.

5.—Breaking up the mold and core.

6.—Cooling castings very slowly.

The Second Function of Chills

Thus the second function of chills is to prevent hot cracks in the castings. In a way this is identical with their first function, because in both cases they work by hastening the rate of cooling of one part of a casting as compared to that of another part. But it is in fact a distinct function, in that the ultimate object sought is not to make the casting sound, but to prevent the section which normally cools the faster from pulling away from that which normally cools the slower. A single chill may in some cases exercise both functions.

As we have seen, a light section that cools ahead of a heavier one to which it is integrally attached, often pulls away from the heavier portion so strongly as to tear the metal apart where the two join. Hence we place chills upon the heavier

part, that it may cool and shrink as fast as the lighter portion; and especially we chill the junction point, where the failure tends to come, that it may be sufficiently cold and hence strong when the pull comes to endure the stress without failure. If the steel holds we have attained our first object, but we should not forget that the stress still exists and that the casting must be handled tenderly until the stresses are relieved.

Fillets, Brackets and Tie Bars

Fillets are so well understood that an extended discussion of them is not needed. They consist simply in a rounding off of the sharp interior angle corners of a casting, especially where thick and thin sections join, by means of suitable design of the pattern. The result is that no sharp corner is presented as a starting place for a crack.

Brackets serve the same purpose, and need no more discussion than do fillets. They consist of extra metal in the shape of tie pieces (generally triangular) across corners and places which are apt to crack, and may be considered as portions of a discontinuous fillet of large radius. Both fillets and brackets serve chiefly to reinforce the corners where failure is likely to occur.

Tie-bars are extra pieces of metal used to bridge across from one part of a casting to another, and serve to prevent the shrinkage from warping the casting out of shape. When they are made too strong they may serve their true purpose so well as to overdo it. For if the shrinkage stresses which they resist should become so great that something must go, obviously the weakest part will be the victim. Hence, the tie-bar often has to be so designed that it will be sure to fail before the other portions of the casting; and in some cases it is notched to insure that it and not the casting itself shall give way under the stress, should the latter be great enough to break something.

Breaking Up the Mold and Core

Many castings are so shaped that the resistance of cores or portions of the mold to the shrinkage of the steel will result in the cracking of the work unless the sand is thoroughly

loosened up as soon as the steel is solid. The fillets and brackets, chills, etc., may prevent cracking at the time of solidification, but further cooling with the shrinkage that accompanies it will crack the casting unless the enclosed sand is so loosened that it does not oppose shrinkage. This can be taken care of to a certain extent by making cores in such a manner that they will crush easily when the shrinkage of the steel brings pressure to bear upon them, and (especially in the case of green sand molds) by not ramming the sand too tight, so that it will yield to the pressure of the contracting casting. But many cores, or portions of the mold proper, which are so located that they will seriously oppose the shrinkage of the casting must be broken up with bars soon after the metal solidifies. Frequently also, the resistance of the sand in the cope to the motion of the sink-heads as the casting cools will have the same effect unless the cope is broken up.

Another result of this resistance of the mold to the shrinkage of the steel is to alter the dimensions of the piece to an extent depending upon the total shrinkage and the degree to which it is prevented by the sand. Thus very long castings with many heads will vary somewhat noticeably in length depending upon whether or not the mold is thoroughly loosened up. The reason for this is, of course, that if the shrinkage of the casting is opposed to a sufficient extent to overcome its elastic limit at the temperature existing at the time, the steel yields to the stress and assumes a dimension not proper to it at that temperature. On further cooling, the casting does not shrink to the dimensions it would have attained had its shrinkage at higher temperatures been unopposed. This virtual expansion, which is analagous to that of the outside layers of an ingot which gives rise to pipes, is often sufficient in amount to make a serious difference in the dimensions of long castings.

Cooling the Castings

When the sand of the mold and core has been loosened up the casting may be cooled in several different ways, depending upon the total shrinkage of the steel, its brittleness when cold, and the extent to which the sections vary in size. If the danger of setting up severe shrinkage stresses is not too

great the castings may be allowed to cool off in air. Should there be danger that the stresses set up by this rapid cooling will break the castings, they may be buried in loose sand or ashes and allowed to cool more slowly. Very complicated pieces with widely varying sections, especially of rather brittle steels, cannot be cooled even in sand without danger of cracking, and must be placed hot in a furnace or pit, generally preheated to about the temperature of the castings, and allowed to cool off slowly and uniformly. Even castings of ordinary 0.25 per cent carbon steel sometimes break in two when quite cold, with a noise like a great gun, from the stresses set up by too rapid cooling.

Rough Handling

It is apparent that a cold casting already so full of shrinkage stresses as to be in some danger of breaking, will almost surely crack if these stresses are increased by rough handling. It is advisable in most cases to remove heads and gates before annealing the casting, but we should be careful how we do it. The practice of pounding off heads and gates with a heavy sledge hammer, dolly or drop ball is one to be avoided whenever possible. The stress produced by the heavy blow, added to the shrinkage stresses in the casting, may break or crack the piece. If the casting is of brittle steel, the head breaks off quite easily, but on the other hand the casting itself will break quite easily under a comparatively slight extra stress, especially one applied suddenly. If the steel is tougher, there is less danger of cracking the casting with a blow of given intensity, but the head will be harder to break off, so that the blow must be more severe. Before making a practice of breaking off the heads of castings from a given pattern, it is advisable to be quite sure that there are no cracks, visible or concealed, produced in the process—and then to allow a liberal margin for unforeseen contingencies, and cut or burn off all heads that require more than a comparatively slight blow.

Blow Holes

Blow holes in castings may be due to:

1.—Gases in the steel.

2.—Gases set free from the mold.

3.—Trapped air.

Gases set free from the mold may arise:

1.—From wet spots in dry sand molds, due to (a) imperfect drying, (b) patching.

2.—From binder used in dry sand facings.

3.—From water in green sand molds and binder in facings.

4.—From binder in cores.

The methods by which the steel is freed as far as possible from gases are beyond the scope of this paper, and will not be touched upon further than to suggest that if most of the castings from a heat of steel are sound, it is a poor excuse to say that the unsound ones are due to gassy steel. Some of the bad castings may be due to steel poured too cold to permit the escape of the gas liberated from it, and those set free from the mold; but the chances are that a large proportion of them are due to faulty foundry practice.

Excessive amounts of steam may be liberated from dry sand molds that are insufficiently dried, or on which too much patching has been done and the patch slicked too liberally. If the sand of green sand molds is too moist it may set free too much steam. Too much binder in either dry or green sand may liberate too much gas. Improperly dried cores may steam badly, and cores made with too much binder may liberate too much gas. Any one of these sources of excessive gas may result in unsound castings, in spite of all reasonable precautions for taking care of the normal amount of steam and gas.

Venting

To carry off these gases, we rely upon venting the mold and cores; and in doing so we count upon the sand of the mold and core being sufficiently pervious to allow the gases to flow freely to the vents. Obviously, then, insufficient venting of cores and molds may be the cause of excessive blowholes, or they may be due to the fact that the gases could not penetrate the sand to reach vents that in themselves were large enough to take care of all the gas generated.

Sand in either core or mold may be impervious because rammed too tight, and this is particularly apt to be the case if

it is used too moist, or with too much clay. Excessive amounts of clay and binder may in themselves render the sand impervious. Another source of this difficulty is the use of too fine a sand, which often packs too hard, and is very impervious even when not rammed very tight. Certain foundries in this country have made great improvements in their practice by subjecting their sands not only to analysis, but to screening tests. The selection of sand that conforms to certain specifications for fineness of particles has led to the elimination of much "unexplained" trouble with blow-holes.

The escape of the gases from many molds and cores is much facilitated by the use of loose cinders overlaid with sufficient sand to hold the part in shape. By thus reducing the thickness of rather impervious molding sand and substituting for a large part of it a loose material, we allow the gases to penetrate more easily to the vents provided.

Surface Imperfections

The commonest causes of surface defects in castings are:

1.—Cold steel, resulting in "cold shuts," etc.

2.—Entrained slag.

3.—Insufficiently refractory sand, which burns to the steel.

4.—Steam, gases or trapped air, causing surface blow-holes.

5.—Loose sand, caused by cutting of mold or dropping of cope.

For most of these causes of defects the remedy is obvious. The troubles from cold steel are sometimes due to the use of gates and runners either too small or badly arranged. This question has been discussed at some length above. The remedy for entrained slag is easy to give, though not always so easy to apply, and is to keep the slag out. When bottom poured ladles are used this is comparatively simple. With lip pouring it is chiefly a question of care in skimming, and in holding back the small amount of floating slag that can not be removed from the shanks or ladles.

The trouble that is sometimes experienced from sand burning fast to the casting, causing lumps of mingled steel and

sand, is usually eliminated by the use of a more refractory sand put up with as little clay as possible.

Steam and gas sometimes cause many surface blow-holes in addition to those in the interior of the casting. The source of the trouble and the means of eliminating it are the same as in the case of deep-seated blow-holes. Proper venting will reduce this source of loss to a minimum. Surface and other blow-holes sometimes result from the trapping of air or gas in a pocket in the upper portions of a casting, into which the air is forced by the rising body of metal and whence it can not escape. This can be guarded against by placing vertical vents of good size upon these portions of the casting, through which the air may get out.

Loose sand is commonly the result of using a facing and sand with too little binder or clay, which cannot be rammed tight enough to stay in place; of making up the cope with too few gaggers, bars and nails to hold up the sand; or of not using enough nails in parts of the mold where the metal flows rapidly or falls upon the sand hard enough to cut into it. At times, of course, the sand is carelessly left in the mold or dropped down the runner in placing a pouring cup.

Miscellaneous

Of miscellaneous sources of unsoundness and weakness may be mentioned the use of nails or chaplets to hold a core in a light section, which are too heavy to be melted by the small amount of metal poured around them and remain imbedded in the steel but not welded to it. I have seen failures of certain light castings, every one of which had broken at a point weakened by the presence of nails that had not been melted by the metal surrounding them.

Though it is not exactly a case of unsoundness, the spoiling of a casting by the lifting of the cope may properly be discussed here, as it is due generally to misapprehension of the laws of fluid pressure. Let us take, for example, a circular casting having an exposed horizontal surface of two square feet, and provided with three heads each one foot in diameter and two feet high; and a similar casting having an exposed

horizontal surface of six square feet, and provided with one head four inches in diameter and two feet high. In both cases it is assumed that the casting is molded entirely in the drag, and the heads in the cope. Now the upward pressures tending to lift the copes of the two castings when they are poured full of steel, are determined not by the size of the heads, but solely by the *surface areas* of the castings and the *height* of the heads. Thus the pressure is three times as great in the case of the casting with one small head as in that of the casting with three heavy heads, since the height of the heads is the same in the two cases and the areas of the surfaces are as three to one. Were the narrow head of the second casting twice as high as the wide heads of the first, the pressures would be as six to one. This is easily understood when we remember that according to the law of fluid pressure the pressure per square inch at any given point in a body of liquid is equal in all directions, and is dependent only upon the depth of that point below the surface of the liquid.

We thus are obliged to hold molds together with very strong clamps, or to put very heavy weights upon the copes, in cases where though the total weight of the heads is small, their height and the surface area of the casting are considerable. The weights put upon a cope may thus have to be several-fold heavier than the metal in the heads.

Conclusion

This whole subject is a most interesting one and the temptation to elaborate its details is strong. The foundryman who is called upon to produce a great variety of castings is faced daily by new problems, and as they come up they suggest new methods of applying the general principles which I have attempted to set forth. It is difficult on the one hand to avoid too great elaboration, and on the other so to state the broad principles involved that they shall cover all possible cases. I have endeavored to avoid inaccuracy of reasoning and obscurity of statement, and hope I have succeeded sufficiently to make this paper of some interest and value to the many men who are grappling daily with the problem of producing that *rara avis,* the perfect steel casting.

Discussion of Defects in Steel Castings

THE CHAIRMAN, MR. R. A. BULL:—Mr. Hall has gone into the subject of defects in steel castings in an exhaustive manner, and I am sure his paper has been very interesting to all of us. His abstract has been very brief, but the paper covers a great many of the factors resulting in defective castings, thoroughly. We will be glad to have the paper discussed. Mr. Janssen, will you start the discussion?

MR. W. A. JANSSEN:—If I should undertake to criticize the paper my efforts would be very futile. If to discuss the paper means to remind Mr. Hall of some of the things he ought to have handled my efforts would be equally futile. The magnitude and immensity of the subject however are so far-reaching that it is hardly possible to cover it in one single paper or one single session of this convention. I don't know that we would want to do that anyway, because we'd want to come again. The steel foundry without defective castings, I suppose after all is a dream of Heaven. As one of my fellow workers one time said, the steel foundry is much like a dog with the fleas—you look your dog over and wash him and think you have got a pretty fine dog; next day you look at him again and he has more fleas than he had before. It is about the same with the foundry; you look around, find the cause of your troubles, remedy them and then look around again only to find them magnified. As Mr. Hall has suggested there are three general sources for defects in steel castings, namely, metal, molding, and pouring, and there is possibly one other which I will refer to later. The first requisite of any good steel casting must necessarily be good, quiet metal, uniform from heat to heat, metal which is something better than the specifications which we are called upon to fulfill. We Americans in our mad rush for production, low cost and efficiency, possibly have such a vaulting

ambition that we overleap ourselves and fall on the other side. We might better profit by the example of some of our European steelworkers and adopt the motto of the Krupp company, when they say "Good steel means good iron." We are too apt to buy almost any iron and scrap that is offered us. Tin cans and tin scrap never did make good steel. Those of us who have come from foundries that have a uniform product possibly have had a greater opportunity to study metal needs as applied to our particular product, and we have made specifications to meet those conditions, these specifications in fact being something other than standard specifications for pig iron. It is essential that your furnaceman should be able to deliver to you steel of uniform quality. It is necssary that he be provided with pig iron and scrap of quality. We very often ask our furnacemen to try to make the heat in an improperly designed or poorly maintained furnace. It is hardly fair to ask any man to be able to "deliver the goods" under any such conditions. The quality, degree of fineness and the mixture of our molding sands has been previously discussed and mayhap has been the source of experimentation in every foundry. However, it is of great importance that special attention be given to the quality and degree of fineness, the mixture, relative amount of fire clay, old sand or new sand. It has been our experience and it is almost theoretical in a way, that the best facing is made up almost entirely of new sand with just enough fire clay to give it a bond. Shrink heads, their size, location, function, gate, runners, their number, size, shrinkage, cracks—have been most ably discussed by Mr. Hall. The matter of pouring steel is something which has possibly not received the attention which it deserves. Personally, I am of the opinion that as many castings are lost due to improper ladle practice as through any fault of metal or mold. My observations may not be quite in line with the observations of those of you who come from jobbing shops, but the particular product that I have in mind is one in which we do not have very large risers or sink heads, these being little more than vents. The common failing appears to be in pouring metal too fast and as soon as metal appears in

the riser, it seems to be the signal for the ladle man that the mold is filled. It was with particular interest that I read the reference of Mr. Hall to the laws of liquid pressure which liquid steel obeys. It seems the introduction of a phase to which we have given very little consideration. Liquid steel theoretically, as intimated, obeys all the laws of liquids, but the moment the metal enters the mold we have immediately a change from a liquid to a plastic condition. Granted that it might be liquid for a considerably longer time, it has occurred to me that possibly in rapid pouring the metal might be forced through the molds up into the riser, making the ladle man think his mold was filled when in reality insufficient metal had been introduced to fill the cavity. Again it occurred to me that possibly in the low carbon steels there might arise that condition of the cooling as suggested, together with the freezing and that when we might have pipes, blow-holes and checks caused by laws and fundamental principles other than as intimated by Henry M. Howe. I don't know whether this would be true, but it is just as it occurred to me. I have often questioned whether or not the metal as issuing from the ladle was a solid stream and whether or not in this condition of high pressure and rapid pouring the matter of insufficient metal having been introduced into the mold might not further be magnified. We find that condition especially true where we pour from a ladle with a cracked nozzle or a leaky stopper. We certainly have every reason to believe that that kind of a stream as it comes from the ladle is not solid. The fourth factor which may largely determine defects is the matter of the design of the pattern itself. As foundrymen, we are often called upon to make something which I question whether the engineer could make if he tried, but we have no redress, and we have to make it. It seems that there is a lack of understanding among engineers and designers as to the possibilities in casting steel. It is apparently a common notion that because things are possible in gray iron and malleable iron, that they are equally possible in steel. We have conditions and problems entering into steel practice which are unknown in malleable and gray iron, and it occurred to me

that furthering the education of the engineers and designers and strongly advocating changing designs to suit foundry possibilities and considerations, would be a desirable factor in reducing defects. In the reading of Mr. Hall's paper, I was impressed by his mention of the use of chills in overcoming pipes and some other defects of which he made mention. It has been our experience that the matter of design itself may make the chills unnecessary. The product to which I refer is made by several foundries in this country. Several of them find it almost imperative that chills be used. In another foundry a chill is an unheard-of thing but the design has been studied to overcome these conditions and conforms to them. I don't want to say that in refutation of the principles which make chills necessary, but only to further emphasize the importance of the design of the pattern itself and the efforts that the foundrymen should try to make to alter it to meet the possibilities of making it. The several discussions this morning on electric steels, furnace steel and acid steel castings have been very interesting. We from time to time are led to believe that some process other than the one which we are using no doubt will be the cure-all for all ills which we may have. In our trade journals we read much of electric steel and we hear the beautiful side of the story. There is no question but that the electric process steel is in all probability the coming one. We have had a comparison of acid steel with basic steel, but after all the success of any process is dependent upon the melter and we must not forget that we are still in the hands of old-school men and in a great majority of cases rule-of-thumb-trained melters and it resolves itself into that intangible and ungovernable thing in any foundry, personal equation, which, after all, may be the true cause for the greatest number of defects. In this day of alloys and weird claims as oftentimes introduced, many foundrymen have been led to believe that they might be able to use pig iron and scrap of inferior quality, trusting to God and good luck and these ferro-alloys to produce good steel. All the ferro-titanium and all the ferro-vanadium and all these other things you may add will never help steel a bit unless your metal is

receptive. These alloys do perform certain functions, but I don't believe they should be considered as cure-alls. I might add in passing that when these alloys were first introduced we "fell for them" just the same as everybody else. Many of the claims made for them, I believe were absurd, possibly not intentionally so, I don't believe the people marketing them knew all about them themselves. Several months ago we found that we had a quantity of ferro-titanium on hand and began to use it in smaller quantities than had previously been advised. We are now using a pound and a half or two pounds of this alloy per ton and the results have been most remarkable. They have given us an average increased ultimate strength of about 4,000 pounds. An average of 22 heats gives us an average of 68,100 pounds ultimate; that is for an 0.18 carbon steel, 0.18 to 0.20. I presume, I could talk on this way forever, but I don't think we'd cover all the defects nor even guess at all the remedies, therefore, I thank you.

THE CHAIRMAN:—There isn't very much time left, still we have a few minutes for some further brief comment on this paper of Mr. Hall's.

MR. HOYT:—I will say just a few words about the formation of the pipes. I was rather surprised to read this explanation of how piping is formed, because everybody knows that when a molten metal solidifies, that the specific volume decreases. This is about the only exception to that among the metals—if you cast molten metal into a mold, the outer layer crystallizes first. You have solid metal entirely surrounding liquid metal. The specific volume of the solid metal being less, there is a certain difference in volume between the molten and solid metal which naturally goes into the pipe, there is that volume which has to be taken care of in some way or other. There is a process which uses that very property to form solid or sound ingots; that is, they will compress the ingot in the process of solidification by an amount just sufficient to keep up with that change in volume. They do that for a certain kind of steel and there is a large apparatus that forces the plunger up just right for that steel which they are casting so that the ingot will at the moment of solidification

be sound and not under any pressure. I was not aware of this paper by Prof. Howe, in 1907, but it seems to me that the explanation given you is much better than his, with all due respect to Prof. Howe. I am not the author of this theory at all; it is one that is taught in Germany. Prof. Heyn as far as I know, got it up and it seems to me it is the only rational explanation of that phenomenon.

MR. JOHN HOWE HALL:—I think probably in either my paper or my discussion of it I didn't give Prof. Howe's idea quite correctly. Of course the pipe is due to the fact that the molten metal contracts while molten on its way down to the solidification point, and after it solidifies. It wouldn't pipe if it didn't. At the moment of solidification, according to Prof. Howe, the steel might either contract or expand slightly, but while it contracts while a solid, the ingot will pipe anyway, and that is the explanation of why the pipe is in the direction of the expansion of the side layer. I think a proper reading of Prof. Howe's paper will convince the last speaker that he has made a very good case for his explanation.

MR. S. STONEHAM:—I was very much interested in Mr. Hall's paper when he was speaking about gates and risers. One point that interested me most was when he spoke about deep castings and also mentioned pouring molds from the top. He mentioned about having gates on a deep mold at the side, three or four at different parts of the mold. As the metal raised, I would like to ask how he would stop the metal from going through the top gate while he was running it into the bottom of the mold and as the metal came up into the mold, how you could stop the bottom ones to get the hot metal at the top of the mold?

MR. JOHN HOWE HALL:—In answer to that question—I discussed that with several foundrymen and they pointed out that disadvantage. One way suggested was to make those gates slope up in order to prevent the metal flowing through the upper gate first. The metal generally runs down the runner pretty fast and if the gate slopes slightly upwards, it might be possible, I don't say it is, that the metal will confine itself chiefly to the lower gates. As far as stopping-off the

lower gates so the metal will flow through the upper, in a good high casting, I don't think you would have any trouble about that, because the metal has a way of stopping itself off. That is one of the disadvantages of these several gates.

MR. S. STONEHAM:—The pressure of the metal going down the runner would make it impossible for the bottom gate to freeze.

MR. A. F. S. BLACKWOOD:—In a considerable discussion on the basis of contraction we have Howe's theory of the contraction of ingots and segregation. The gentleman to my left discussed it from another angle. The casting of an ingot and a casting are very different. Segregation is simply the flow of contraction. In an ingot the flow of contraction all goes one way all the time. If it is square, it flows from four points to the center. In a casting there is a flow of contraction from all angles and ends to where the flow is, and I think we cannot accept anybody's theory to govern us to overcome segregation in a steel casting. The description or the make-up of the pattern itself would govern how it should be fed. I think it is wrong to use chills in steel castings. In the first place, steel as a metal has as great a contraction as any metal we have, and a slower cooling power; that is, it has a very long plastic condition—that's when it's weakest—and if we don't use very judicious care when it is cooling, it not only will not feed the casting and assist it to be solid, but will crack it every time.

MR. PLOEHN:—I agree with Mr. Blackwood that the use of chills on steel of low carbon in ordinary green sand or dry sand work will throw a strain into the casting and that if there is a strain there which the chill has been placed to overcome, it will transfer the strain into the casting along the side of where the chill has been placed and will show up in service. I have never seen that to fail in such castings as couplers, truck frames, bolsters and the general run of steel castings used for impact or below carrying members. I should not say this applies to machine castings or castings of a large nature, but to ordinary steel castings, and my experience has been that

by changing the pattern I have been able to overcome the faults of the original design so that it was not necessary to use chills. I have never seen the casting yet that you could not take care of without chills unless one section of the casting was three times thicker than the other and very abruptly joined. Even in that case brackets could be used better than chills. As Mr. Blackwood says, chills don't do a bit of good, but do harm, and simply transfer the strain to some other place and usually alongside of it, but those things don't show up until after the castings have been in service.

Annealing and Heat Treating Steel Castings

By William Campbell, Ph. D., Sc. D., New York.

In a former paper[1] the methods for microscopic examination were given, the iron-carbon diagram was briefly explained and examples given of type structures, effects of heat treatment and of faulty material. The present paper will deal with the grain-refining of steel castings by heat treatment, the effect of rate of cooling, and give cases where complete refining is impossible.

All metals as cast are built up of cuptalline grains, whose size and shape depend on the rate of solidification and on the shape of the mold. Fig. 1 shows sections of two small ingots of zinc, one cast wide end up, the other with the wide end down. From the sides of the mold the well-known columnar crystals have grown out, shrinkage has followed and the usual pipe has formed. The difference in the depth of this pipe is well shown. In the case of the left-hand ingot the cooling from the base was more rapid and solidification therefore quicker here. In consequence the crystals in the center still retain their columnar structure up to the middle of the ingot. In the other ingot, solidification at the base was slower, resulting in the formation of grains more or less equidimensional in the center of the ingot.

In Fig. 2 we have the fracture of a runner of a steel casting. The columnar or dendritic crystals can be seen growing from the sides, while the center which was piped shows the characteristic octohedral crystals. Now impurities which are not soluble in the metal are found entangled in these dendrites, and are found to be more or less segregated at the boundaries of the octohedral crystals in the center. This is true of manganese sulphide and silicate in steel, and these play an important part in the practice of annealing or refining steel, as will be shown later.

[1]—On the microscopic structure of iron and steel. Trans. A. F. A. XX, 519.

In the case of a metal or alloy which has no critical points or transformations in the solid state, the structure of the original casting can only be broken down by mechanical means. In other words we can only grain-refine by forging, rolling, etc., as for example such metals as copper, lead etc., alloys like german silver, monel metal, gun metal, red and yellow brass. When transformations in the solid do take place we can grain-refine by heat-treatment as in the case of iron and

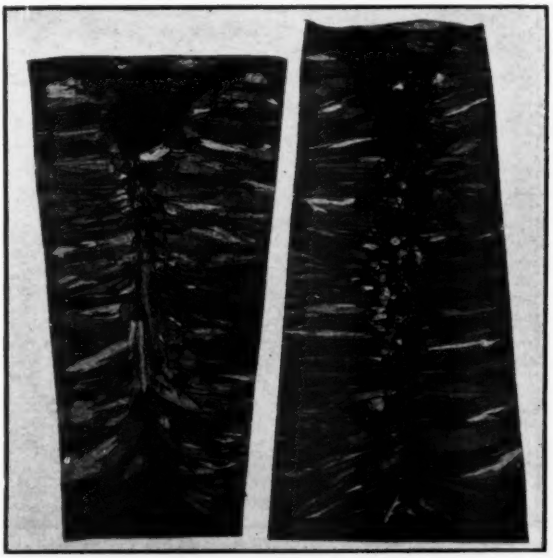


FIG. 1—SMALL ZINC INGOTS SHOWING METHOD OF FREEZING

steel, hard aluminum bronze, bell-metal, etc. The thermal diagram in all cases must give the key to efficient heat treatment.

In Fig. 3 is given part of the iron-carbon diagram which is still not quite settled, as was explained in a former paper. The question has been most carefully and thoroughly discussed in Guertler's Text-book of Metallography, Part II. However that part of the diagram in which steel occurs is settled for all practical purposes, the only point of discussion being

the location of the point A at 1135 degrees Cent. and 2 per cent carbon according to the older authorities and 1.7 per cent according to some recent observations.

In brief, all steel above the curve G O Sa, consists of a homogeneous solid solution of carbon in iron, called austenite or gamma iron. In the area G O S P, we have ferrite (alpha or beta) plus austenite. In the area SaK we have

FIG. 2—FRACTURE OF A RUNNER ATTACHED TO A STEEL CASTING

austenite plus cementite, the carbide of iron Fe_3C. Below PS steel consists of ferrite plus pearlite (the mechanical mixture of ferrite and cementite,) while below SK we have cementite plus pearlite.

First it must be emphasized that the point S at 720 degrees Cent. and 0.9 per cent carbon moves more or less, depending on the amount of manganese, rate of cooling, etc. For example with 1 per cent manganese and small sections cooled in air, S occurs at 0.6 per cent carbon and 660 degrees

Cent. In other words such a steel is composed entirely of pearlite. Similarly the line P S K is lowered by the presence of manganese, nickel, etc.

A steel casting with less than 0.9 per cent carbon, when cast consists of grains of the solid solution austenite whose size depend on the rate of solidification. On cooling down there is no important change in structure until the temperature reaches the line G. O. S., when ferrite or pure iron begins to

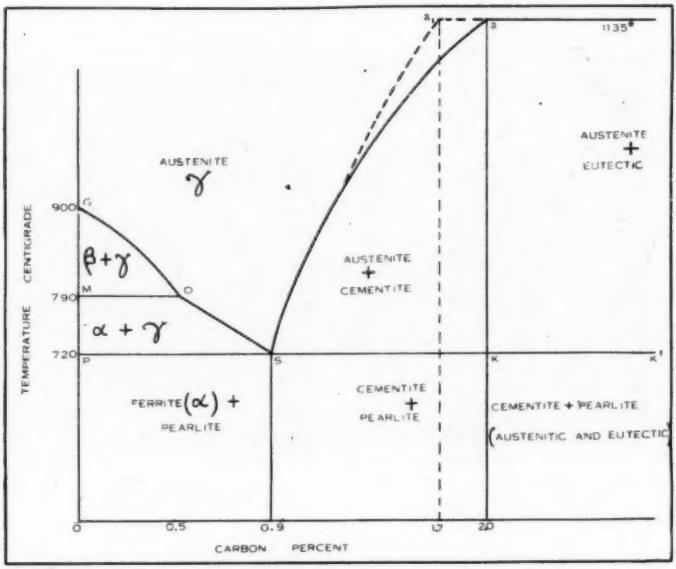


FIG. 3—PORTIONS OF THE IRON-CARBON DIAGRAM

separate out around the grain boundary as an evelope and within it as patches and plates, and continues to separate out until at the temperature PS the residual grain contains 0.9 per cent carbon and breaks up into the mechanical mixture, pearlite, with more or less recalescence due to undercooling. Hence the structure is coarse, the grain size being that of the original solidification, Figs. 4, 5, 8 and 9.

Similarly a steel with over 0.9 per cent carbon, but in this case the first change occurs when the temperature reaches the curve Sa, where cementite begins to separate out as a thin envelope around the grain and within it as thin plates and spicules, and continues to precipitate until the temperature SK is reached when the residual grain of austenite contains 0.9 per cent carbon and splits up into pearlite as before, Fig. 17.

Conversely on heating a steel casting with less than 0.9 per cent carbon, when the temperature PS is reached the pearlite changes over into the solid solution austenite, whose

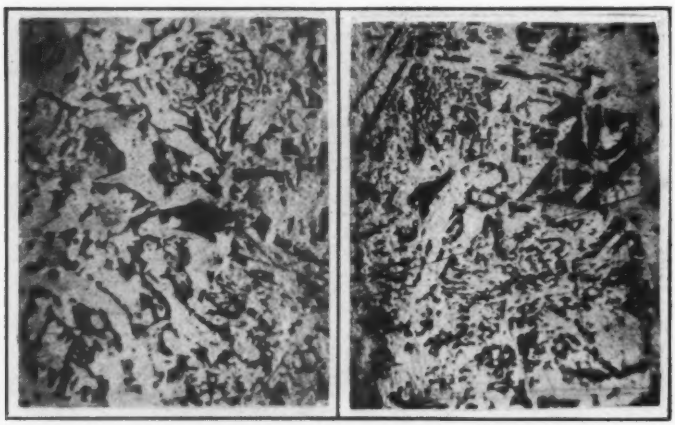


FIG. 4—SECTION OF CAST STEEL CONTAINING 0.27 PER CENT CARBON

FIG. 5—SAME STEEL AS SHOWN IN FIG. 4, NEAR CENTER OF PIECE

grain is of minimum size. As the temperature rises the austenite dissolves more and more ferrite until on passing the curve G O S, all of the ferrite has disappeared, and we have the finest grained austenite it is possible to obtain. On further heating, the higher the temperature the coarser the grain, the rate of increase being much greater at the higher temperatures. Hence we obtain the finest possible grain by heating to just above G O S and cooling.

Similarly for steel with over 0.9 per cent carbon. At SK the pearlite becomes austenite and as the temperature rises

more and more cementite is dissolved until on passing Sa, it has all disappeared. Hence to obtain the finest grain possible, heat to just above Sa and cool.

But the higher the carbon the more rapid is the increase in grain size of the austenite as the temperature is raised above P S K. Hence, with very high carbon steel, heating to

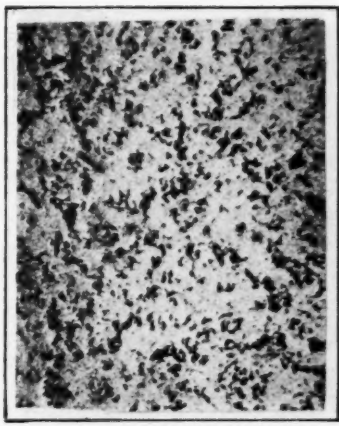


FIG. 6—STRUCTURE OF STEEL SHOWN IN FIG. 4 AFTER HEATING AND AIR COOLING

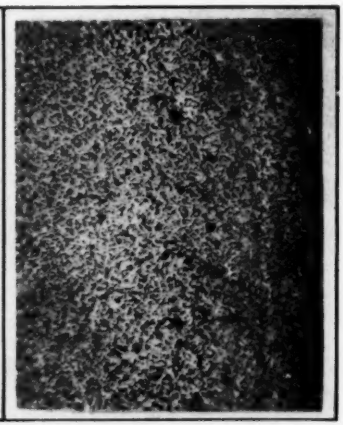


FIG. 7—STRUCTURE OF STEEL SHOWN IN FIG. 4 AFTER HEATING AND COOLING IN FURNACE

Sa to get rid of the last of the envelopes of cementite, often results in the formation of a comparatively coarse grain. However, very high carbon steels are rarely used as castings, where a fine grain is required. In short to refine any steel casting, heat to just above G O Sa, and cool.

The rate of cooling after refining is important. In general the more rapid the cooling the finer the texture. Figs. 6 and 7 are air cooled and furnace cooled respectively. Similarly Figs. 10 and 11. Now the finer the structure the tougher the material. This is made use of in water and oil toughening. By quenching in water or oil from G O S down to a black heat, followed by annealing at 550 to 650 degrees Cent. we obtain material which is far stronger and tougher than by simple grain refining.

The effect of manganese sulphide and silicate is also very important. If these occur as isolated globules their effect is but slight. If they form envelopes around the grain as in Figs. 8, 9, 14 and 15, they not only weaken the material, but they also prevent complete refining because the ferrite tends to reprecipitate on these envelopes and a coarse structure results.

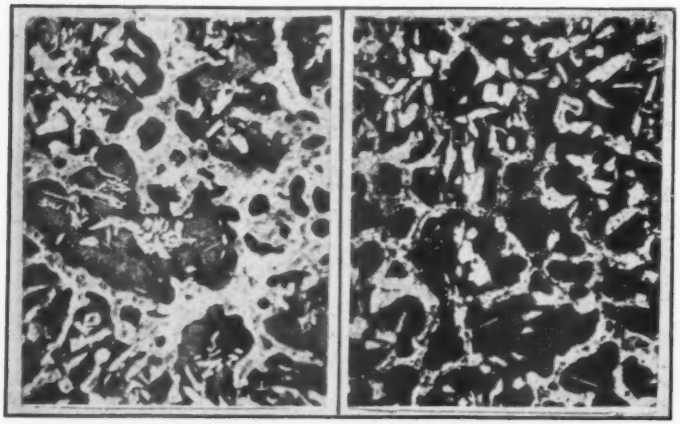


FIG. 8 — SECTION OF STEEL CONTAINING 0.30 PER CENT CARBON, NEAR OUTSIDE OF CASTING

FIG. 9—SAME STEEL NEAR CENTER OF CASTING

The following examples will illustrate the above.

Steel No. 1. C = 0.27. Mn. 0.56. Si. 0.23. Manganese sulphide as well distributed globules.

Fig. 4. As cast, section near outside of casting.

Fig. 5. As cast, near center of this piece. The structure is very coarse, consisting of white ferrite and dark-etching pearlite. In the ferrite are seen a few small black globules of manganese sulphide.

Heated to 750 degrees Cent. the pearlite was refined but the coarse ferrite was hardly changed.

Heated to 775 degrees Cent. the ferrite was partly dissolved, but the coarse structure remained.

Heated to 800 degrees Cent. or G O S the specimen was refined. Fig. 6 is air cooled. Fig. 7 cooled in furnace, the difference between the two being very marked. Now a heavy casting cools as slowly in air as a small one does with retarded cooling, hence in a heavy section we cannot get a finer structure than Fig. 7 even when air-cooled.

Steel No. 2. C = 0.30. Mn. 1.01. Si. 0.42. Manganese sulphide globules occur as a network around the grain.

Fig. 8. As cast, section near outside of casting.

Fig. 9. As cast, near center. The structure is coarse and cellular due to the manganese sulphide on which the ferrite has precipitated.

Heated to 750 degrees Cent. the pearlite within the cells is refined, but the ferrite is unaltered.

Heated to 775 degrees Cent. brings about a partial solution of the ferrite, but the cell structure is still very pronounced.

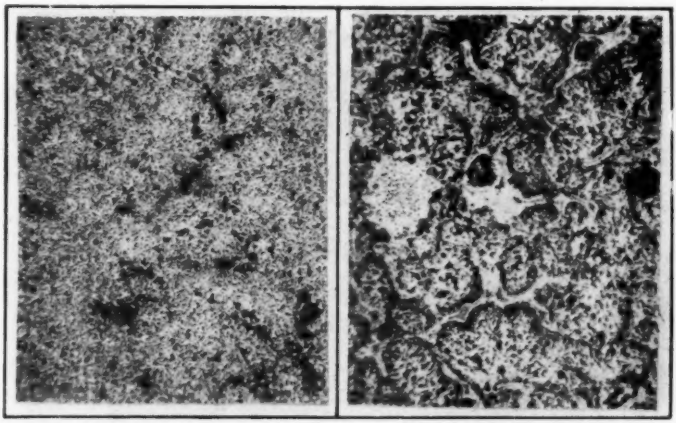


FIG. 10—SAME STEEL AS SHOWN IN FIG. 8 AFTER HEATING AND AIR COOLING

FIG. 11—SAME STEEL AS SHOWN IN FIG. 8 AFTER HEATING AND COOLING IN FURNACE

Heated to 800 degrees Cent. or G O S and air-cooled, the specimen is refined as in Fig. 10, where the grain is as fine as possible, and the network of manganese sulphide shows up as a dark outline. When cooled in the furnace, however, the metal remains unrefined as in Fig. 11 because the ferrite has reprecipitated on the network of manganese sulphide and the cell structure therefore persists.

Heated to 900 degrees Cent. furnace cooled is shown in Fig. 12. Still unrefined. Similar results at 1000 degrees Cent.

In all of the above the temperature was kept constant for one hour before cooling. In many cases the form of the manganese sulphide follows the dendritic structure of the austenite, especially near the outside of castings. This persists due to the reprecipitation of ferrite as above. Fig. 16, a steel with C = 0.50. Mn. 0.68, heated to above G. O. S., then reheated to

735 degrees Cent. magnification, 25 diameters. The dendritic structure is emphasized by the precipitation of the ferrite on the manganese sulphide.

The presence of slag causes results similar to manganese sulphide and prevents refining. Fig. 13, 14 and 15 show a section from a faulty spot in an engine frame, magnified 50 diameters. In Fig. 13 the lower half is composed of characteristic coarse grained mixture of ferrite and pearlite, the former with the characteristic structural arrangement in plates within

FIG. 12 — SAME STEEL AS SHOWN IN FIG. 8 AFTER HEATING TO 900 DEGREES AND COOLING IN FURNACE

FIG. 13—SECTION FROM A FAULTY SPOT IN ENGINE FRAME CASTING

the grain. The upper half shows a black mass of enclosed slag. In Fig. 14 the dendritic structure of the steel is brought out by the entangled slag. Fig. 15 shows the cellular structure induced by the envelope of globules of manganese sulphide and slag similar to that in Figs. 8 and 9. While such material could be improved by heat treatment especially when followed by comparatively rapid cooling, it could never be made very tough and strong.

Further examples could be given showing that with increase in carbon the grain-refining temperature is lowered

until with 0.9 per cent carbon refining is complete at S or, say 720 degrees Cent., because the steel being composed entirely of pearlite, changes over at that point directly into austenite and is completely refined.

While steel with carbon of 1 to 2 per cent is not commonly used in the form of heat-treated castings an example will be given to show that such steel behaves normally and follows the thermal diagram. Rolled material, especially in small sections, often behaves differently and graphite is precipitated.

FIG. 14—ANOTHER PORTION OF THE CASTING SHOWN IN FIG. 13

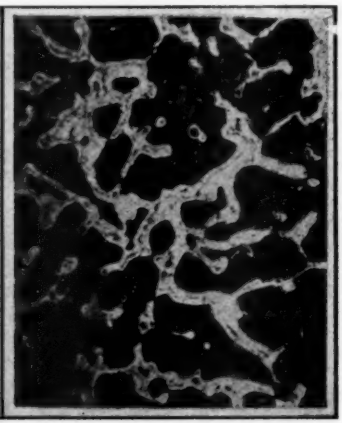


FIG. 15—ANOTHER PORTION OF THE CASTING SHOWN IN FIG 13

Steel No. 3. Crucible ingot C = 1.43.

Fig. 17. As cast, shows very coarse grains with thin envelopes of cementite around the grain and plates and spicules within it.

Heated to 750 degrees Cent. for one hour and furnace cooled caused little change beyond making the texture of the pearlite coarser. Cementite envelopes and needles unaltered.

Heated to 775 degrees Cent. gave similar results and in addition the cementite plates seem to thicken by reprecipitation.

Heated to 850 degrees Cent. cementite envelopes very thin, plates now blurred, but still unrefined.

Heated to 900 degrees Cent. Fig. 18 shows the refining to be complete in the lower half but the grain is starting to coarsen again in the upper half which is in the neighborhood of a blow hole.

Heated to 950 degrees Cent. coarsens the grain again considerably and at higher temperatures overheating is pronounced.

Heated to 1030 degrees Cent. for five hours merely produced a very coarse grain, but no graphite was precipitated. When we heat high carbon steel which has been worked down to a small section, especially when the work has been cold enough to cause a marked lamination or streakiness in the cementite, graphite is liable to be precipitated through the decomposition of the cementite, and overheating occurs at a comparatively low temperature.

Steel No. 4. C = 1.9. Crucible, rolled to 5/16 inch square.

As rolled, consists of small grains of pearlite, more or less elongated, with envelopes of cementite which in many cases are thick, giving the structure a laminated appearance.

On heating to just above the line SK the cementite envelopes break up into globules and the steel is refined although much below the theoretical refining temperature Sa.

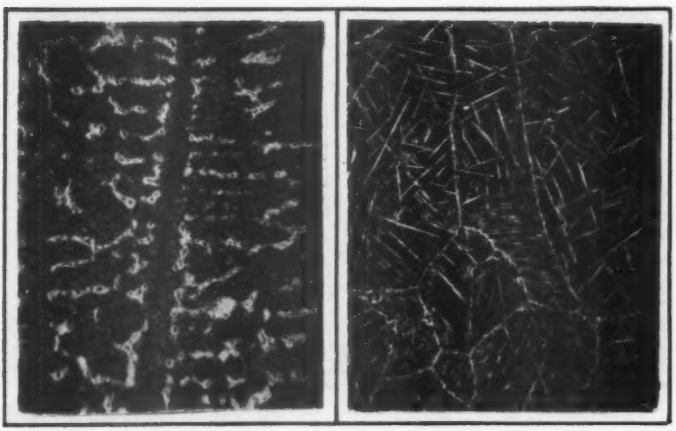


FIG. 16—A STEEL OF PECULIAR STRUCTURE

FIG. 17—SECTION FROM STEEL CASTING CONTAINING 1.43 PER CENT CARBON

Heating to 950 degrees Cent. for five minutes or 850 degrees Cent. for four hours caused the precipitation of graphic, which increases in amount as the temperature is raised.

Fig. 19 shows the specimen heated to 1030 degrees for five hours. The black streaks and dots are the graphite surrounded by white envelopes of ferrite, the whole set in coarsely laminated pearlite.

In conclusion, too much emphasis cannot be put on the fact that in the heat-treatment of steel the changes or transformation are never instantaneous, but require time. The larger the section the longer the time required for the heat to

become uniform and the changes complete. In heating, the various transformations occur at higher temperatures than on cooling down, due to lag. This is specially true for rapid heating, high manganese, high nickel, etc.

In heat-treatment of castings it is much safer to go above the refining temperature G O S than risk being below it. If below, the material remains unrefined and brittle; if above,

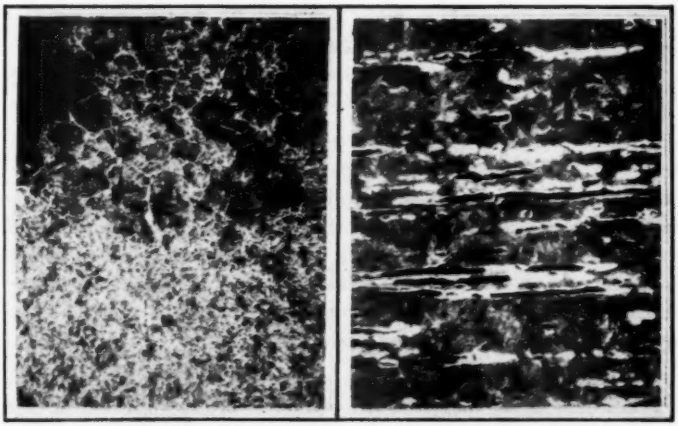


FIG. 18—SAME STEEL AS SHOWN IN FIG. 17 HEATED TO 900 DEGREES AND COOLED

FIG. 19—SPECIMEN OF STEEL CONTAINING 1.9 PER CENT CARBON, HEATED TO 1030 DEGREES FOR FIVE HOURS

it requires a relatively high temperature to materially coarsen the grain to the point where brittleness due to overheating sets in. The lower the carbon the higher may be the heat without overheating.

The effect of mass in heat treatment of steel is often of more importance than precise temperature.

Report of Committee on Steel Foundry Standards

By Dudley Shoemaker, *Chairman*

Your committee appointed to investigate the possibilities of standardization of features of steel foundry practice, has been engaged during the past year in the investigation of possibility of standardization of nozzle brick in connection with ladle equipment.

As a result of Mr. Bull's paper on some trouble encountered in pouring steel castings, which was read at our 1913 convention, it was decided to go into the matter of standardization of nozzle brick, with the idea of cutting down the very great number of different designs that the brick people now have to supply in small quantities to the numerous foundries and in so doing make it possible for them to improve the quality of the brick by large scale production.

Your committee has made a very thorough investigation of the methods of manufacture of nozzle brick, and have found that the brick people will welcome any move on our part in the way of standardization, as the nozzle business for the steel foundries forms only a very small percentage of their total business. The troubles that various foundries have had in the past with nozzle brick, on account of the quality, are well known to all, and the subject in this regard is very well covered by Mr. Bull and Mr. Ploehn at our last convention. The only remedy for these troubles seems to be the standardization of design for all of the steel foundries of this country, so that the large user and the small alike can be assured of a uniform product properly selected with regard to its constituent materials, and properly tempered before being put in the kiln, and properly treated in the kiln.

Your committee has found that there is absolutely no reason why a uniform product cannot be obtained with regard

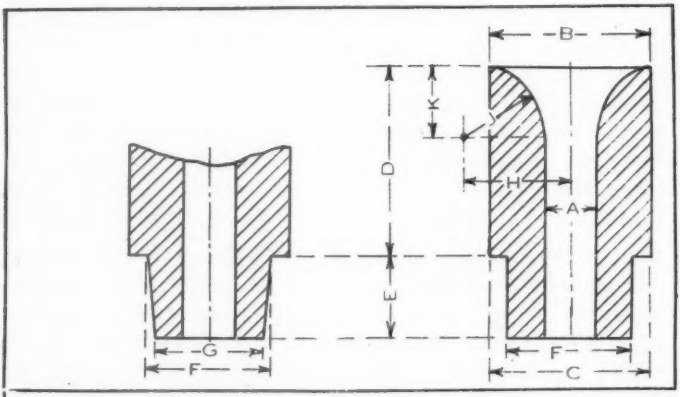
to nozzles any more than with regard to the very best grades of clay brick. The trouble has not been that of the unwillingness of the brick makers to supply satisfactory material, but rather on account of the fact that quick delivery demands have been made on small quantities, and repeated changes in design have had to be met by the brick makers, with a result that the manufacturers have become discouraged over the possibility of working up a profitable business among the steel foundries, treating the matter rather as a side issue, depending on their standard designs of brick for their profit, and taking care of the requirements of the steel foundries with regard to nozzles in order to keep in their good graces.

That the standardization of this feature of steel foundry practice will be of great benefit to all of the steel foundries, as well as to the brick makers, cannot be denied, therefore your committee on this subject respectfully suggests that the standard nozzle design that is submitted, herewith, as being satisfactory for all steel foundry practice, be given at least a fair trial by all of the members of this Association.

Your committee realizes that it is an utter impossibility to please everybody in a matter of this kind. Certain results in certain foundries are supposed to come from certain peculiar shapes, sizes and angles and radii in connection with the nozzle. It is the opinion of your committee that in a great many cases this is merely a matter of sentiment on the part of shop men, and that once a standard design has been given a fair trial, satisfactory results will be obtained, and it will be decided to continue the use of the design of nozzle decided on by your committee.

In compiling the standard your committee got in touch with forty-two of the principal steel foundries of this country. All of the big manufacturers of steel castings are represented, and while the nozzle decided on by the committee does not represent the exact average of all the dimensions received, there have been few radical departures from the average, the aim of the committee being, of course, to decide on a design that would be most easily adopted by all. There

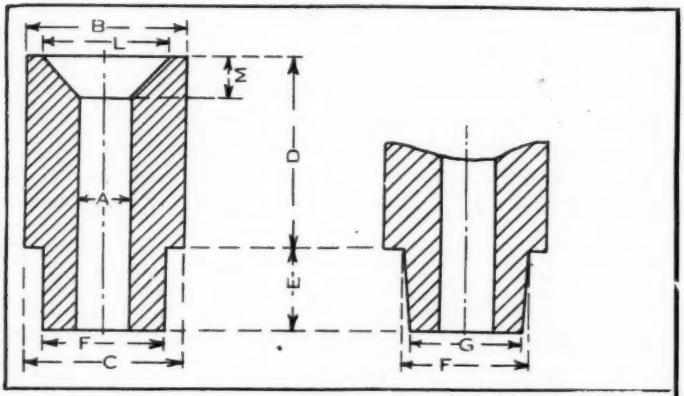
appears to be an equal division of opinion in regard to the relative desirability of the round face and straight face nozzle. This being the case, your committee recommends that two



Name of Foundry.	Dimensions in Inches									
	A	B	C	D	E	F	G	H	J	K
Birdsboro Steel..	2½	5 7/8	5 3/8	4¾	2¼	4½	4¼	2½	1¼	1¼
Birdsboro Steel..	3	5 7/8	5 3/8	4¾	2¼	4½	4¼	2¾	1¼	1¼
Bucyrus Co.	2	7	6½	4	1 7/8	4 3/8	4	3	2	2
Cleveland Steel..	2	6½	5 5/8	5 1/8	2	4 3/16	4 1/8	3½	2 7/16	2 3/8
Chester Steel....	2	5 7/16	4 7/8	4 7/8	1 7/8	4	3¾	2½	1½	1½
General Electric.	2	5½	4 7/8	4	1½	3¾	3 5/8	3 1/16	2 7/16	2 3/16
General Electric.	2	5½	5	4	1½	3 5/8	3 5/8	3¼	2¼	2 1/8
Monarch Steel...	1½	5¼	4 7/8	5	1½	3½	3½	3	2¼	2 1/16
A. J. Haw & Sons.	2	4¾	4½	4	1¼	3¼	2¾	1 7/8	1 1/8	1 1/8
Duquesne Steel..	1½	5	5	4	2½	3 5/8	3 5/8	3 1/8	3¾	3½
Jones & Laughlin.	1½	5 5/8	5 5/8	8½	1¼	4 1/8	4 1/8	2¾	2	2 1/16
Jones & Laughlin.	2¼	5 1/8	5 5/8	8½	1¼	4 1/8	4 1/8	2¼	2	2 1/8
Lawrence Steel..	1¾	4¾	4¾	4	1¼	3¼	3	3 3/8	2½	2½
McConw'y&Torl'y.	2	4 9/16	4 9/16	7	1½	3 1/16	2 11/16	3 1/16	2	1 7/8
Mesta Machine..	2½	5½	5½	5¼	1¾	4 1/16	4 1/8	2	¾	¾
Mesta Machine..	3½	6¼	6¼	5½	1¾	4 7/8	4½	2½	¾	¾
Ft. Pitt Foundry	3	5½	5½	5	1 3/16	4½	4¼	2½	1	1 1/8
Com'wealth Steel	2½	5 1/8	5 1/8	6½	1½	3½	3¼	2 1/8	1	1¼
Scullin-Gallagher.	2	6	6	5½	1 5/8	3¾	3	3 1/8	2¼	2¼
National Steel...	2	4¾	4¾	4 1/8	1½	3 1/16	2½	3½	2½	2¼
Buckeye Steel...	1½	6 3/16	6 3/16	5¾	1 5/8	3 7/8	3 1/16	3 3/16	2 7/8	2 7/8
Falk Co.....	2½	5½	5½	3¾	1 7/8	4	4	...	...	...
Falk Co.....	2	4½	4½	3¾	1 7/8	3 1/8	3	...	...	...
Amer. St'l Fdys.	2	6¼	6 1/16	4 5/8	2	4 5/8	4½	3½	2½	2¼
Pittsburgh Steel.	3	5 3/8	5 3/8	4½	1 1/16	3¾	3 3/8	3	1½	1 1/8
Prime Steel.....	1¾	6	6	4	1 5/8	3¾	3	3	1 7/8	1¾
Otis Steel.....	2½	6	5	4¾	2	4½	4½	...	...	...
Average.	2 3/16	5 3/16	5 1/8	5	1¾	3 21/32	3 21/32	2 23/32	1 11/16	1 31/32

NOZZLES IN COMMON USE IN STEEL FOUNDRIES.

general designs of nozzle be decided on as the Association standardization, one having the round face and the other the straight face. Your committee recommends that five sizes



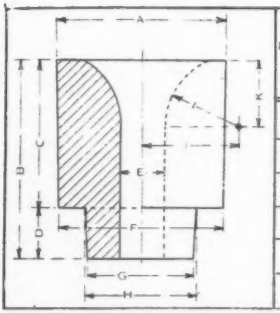
Name of Foundry.	Dimensions in Inches								
	A	B	C	D	E	F	G	L	M
Wellman-Seaver-Mor..	2	5½	5	5	1	4	4	4½	7/8
Union Steel	2½	5¼	4 13/16	4½	1½	3 7/8	3 5/8	4½	11/16
National Malleable...	2 1/16	6	5 13/16	5 7/8	1 3/4	4 1/8	3 3/4	5¼	1 7/8
National Malleable...	...	5 1/8	4 7/16	3 7/8	1½	3	2½	5 1/8	1 1/8
National Malleable...	...	5¼	5	4 1/8	1½	3 3/4	3¼	5¼	1½
American Bridge.....	3	5½	5 1/8	5 3/4	1½	4	4	4½	1
American Bridge.....	2	5½	5 1/8	6¼	1½	4	3	4½	1 1/2
Columbia Steel.....	2	5¾	5 1/8	5	1¾	4 3/8	4 1/8	4½	1/2
Hubbard Steel.....	2½	6	5 3/8	6 3/8	3	4½	4¼	4¾	3/4
Seaboard Steel.....	2 3/8	5¼	5 1/16	4 3/8	2	3¼	3 1/8	3¼	3/4
Wheeling Mold.....	3	5 7/8	5 7/8	7	2¾	4½	4½	5 5/16	1¾
Baldt Steel.....	...	6	6	4	2	5	5	4	3/4
Baldt Steel.....	...	6	6	4 3/8	2	4¾	4½	3 1/8	1/2
Allegheny Steel.....	2	6	6	7	4	4½	4½	4¾	1½
Detroit Steel.....	1¾	5¾	5¾	6¼	2	3½	3½	4¼	1 1/8
National Foundry....	2	5½	5½	4½	3	3½	3½	4½	1
Ohio Steel	1½	5¾	5¾	7	1 7/16	4½	4½	4 1/8	...
Ohio Steel	3	5¾	5¾	7	1 7/16	4½	4½	5	...
Penn Steel Castings.	2	4 1/16	4 1/16	3 3/8	2 3/8	3¼	3¼	2¾	3/8
Penn Steel Castings.	2½	6¼	6¼	4 3/8	2	4¼	4 5/8	3½	2 9/16
Penn Steel.....	2½	7	7	4	1¾	4¾	4¾	6	1/16
St. Louis Steel.....	1½	5¼	5¼	4¼	1½	4 1/8	2 7/8	4¼	1¼
Strong Steel	1½	5¼	5¼	4½	2 1/8	3½	3	4¼	1 1/8
American Steel Fdys.	2	5 1/16	4 11/16	7	1¾	3 3/8	3 3/8	4¾	1 1/8
Bettendorf Co.	1¾	5 3/8	5 3/8	6¾	2½	3¼	3¼	4¾	1 1/8
Average	2¼	5 5/16	5 11/32	5 11/32	2	4	3 13/16	4 7/16	1 3/32

NOZZLES IN COMMON USE IN STEEL FOUNDRIES

of nozzles be decided on for each of the general designs, the sizes to be as follows:

1½-inch diameter hole.
1¾-inch diameter hole.
2 -inch diameter hole.
2½-inch diameter hole.
3 -inch diameter hole.

The outside diameter of the smaller size nozzles might appear to some to be a little bit too large, but it was decided that it would be best to keep this dimension constant for all sizes of nozzles, and this decision was reached because we believe that it would be good policy to make the dimension



DIAMETER OF NOZZLE	A	B	C	D	E	F	G	H	I	J	K
INCHES	INCHES										
1½	6¼	6¾	5	1¾	1½	6¼	3⅝	3¾	2½	3¼	2¼
1¾	6¼	6¾	5	1¾	1¾	6¼	3⅝	3¾	2⅝	3¼	2⅛
2	6¼	6¾	5	1¾	2	6¼	4½	4⅝	2½	3½	2¼
2½	6¼	6¾	5	1¾	2½	6¼	4½	4⅝	2¼	3½	2
3	6¼	6¾	5	1¾	3	6¼	4½	4⅝	2	3½	1¾

STANDARD DESIGN FOR ROUND FACE NOZZLES.

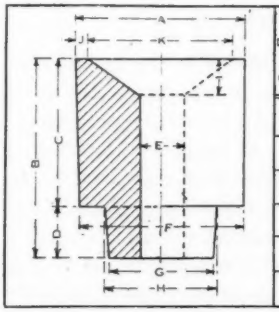
of the brick generous, on account of the importance of its work. When it is realized that the successful casting of twenty tons of metal or over depends upon the ability of a small clay brick to stand up under a severe temperature, as well as under hard mechanical usage, the wisdom of this decision can be realized.

It had been recommended by your committee that certain specifications should be drawn up in regard to the relation of the degree of hardness of the clay to the temperature that the standard nozzle must withstand in order to meet requirements of steel foundries. Your committee, upon investigation, finds that it is impossible to tell what degree of hardness has been obtained in baking, other than testing with a blunt instru-

ment by hand. The constituency of the clay cannot be determined by analysis, and each manufacturer must decide for himself what kind of clay will be satisfactory for his purpose.

It is the opinion of your committee that brick makers should distinctly understand that this standardization is of particular interest to the steel foundrymen only. They should be made to realize that because a particular product gives satisfaction in rolling mill ingot practice, is no criterion of its usefulness in the steel foundry, where the most severe service is encountered.

Accompanying this report we present a pair of tables giving



DIAMETER OF NOZZLE	A	B	C	D	E	F	G	H	I	J	K
INCHES	INCHES										
1½	6¼	6¾	5	1¾	1½	6¼	3⅝	3¾	¼	⅜	5
1¾	6¼	6¾	5	1¾	1¾	6¼	3⅝	3¾	1/16	⅜	5
2	6¼	6¾	5	1¾	2	6¼	4½	4⅝	¼	⅜	5
2½	6¼	6¾	5	1¾	2½	6¼	4½	4⅝	1/16	⅜	5
3	6¼	6¾	5	1¾	3	6¼	4½	4⅝	1/16	⅜	5

STANDARD DESIGN FOR STRAIGHT FACE NOZZLES.

the results of a canvass of all the principal steel foundries of this country, following which are two tables, one showing the 5 standard sizes of round face nozzles and the other showing five standard sizes of straight face nozzles. These tables will be forwarded to all the brick makers who make nozzles, with the statement that they represent the standard nozzle as decided by the American Foundrymen's Association Committee, and with request that they prepare molds in the anticipation of orders on nozzles of these designs. It is obvious that the success of this scheme depends on the co-operation of all of the members of this Association, and it is earnestly hoped by the committee that their efforts will be appreciated by the other members of the Association to the extent of giving the stand-

ard nozzle as decided on by the committee, a thorough try-out, with the idea of adopting it should no troubles be encountered with respect to design.

It has been suggested that there may be other features of steel foundry practices on which standardization might be of benefit to the members of this Association. There have been several suggestions made along these lines, but your committee has thought it best to leave this matter to the decision of the members and we would like to open up a discussion in this regard.

Discussion

MR. DUDLEY SHOEMAKER:—I would like to say in this connection that on account of the necessity of having a meeting of the committee just prior to the opening session of this convention, it was impossible to get this report printed. However, I have here a large number of blue prints that represent standards that have been decided on by the committee, which I will have distributed to any of those who are interested. It would be the best endorsement of the committee's efforts that it is possible to give if you would all take these prints home and try out some of these nozzles. We realize the impossibility of telling the foundries what they have to do in connection with any detail of their business. There is always somebody in the shop that has some particular idea about each detail of foundry practice which he won't give up except under pressure, and if anything is to be accomplished at all along the lines of standardization, we must bring that pressure to bear. There is no question but that a lot of good can be done by a committee of this kind. The chairman has received suggestions from several of the foundries with reference to going into this thing extensively. It was thought best for the present to confine our work to nozzle design and find out how the foundries lined up before going any further. We don't want to interfere with the business of the various foundries, but we feel that it is not in the matter of design, it is more in the matter of application and

use of the equipment that success or failure is determined. I would like to hear a general discussion of the possibility of standardization and other features, if it is Mr. Bull's desire.

The CHAIRMAN, MR. R. A. BULL:—I happen to know that Mr. Shoemaker has given a great deal of study to this question and the fact that he secured detailed data from 42 different steel foundries is indicative that the committee has been anxious to work out a standard that would meet with everybody's satisfaction. I think that Mr. Shoemaker is to be complimented for his valuable work on this committee, and that some action on the part of this session would be in order as indicating the sense of the members present concerning this standard which has been suggested for trial.

MR. A. W. GREGG:—I move that the committee's report be accepted and that the standard nozzles be tried out.

(Motion was Seconded and Adopted.)

MR. PLOEHN:—I would like to make a suggestion with reference to this. I want to support Mr. Shoemaker in this matter. Now if any of you gentlemen want to make any suggestions or any improvements, let that come through the committee chairman's hands. We are not saying that these designs are perfect, but let us work along one line and if it seems that any improvements could be made don't tell your nozzle man to do this or that with his nozzle and get your particular manufacturer to make them one way while somebody else makes them another—that is going to be the danger. To give these nozzles a good trial, there ought to be a report made in some way, good, bad or indifferent, to the chairman of this committee, with reference to their action, so that any changes that might be necessary can be made intelligently; otherwise after six months the designs will be just like they have been in the past, little variations made here and there that don't amount to a "tinker's darn" and then you will get back to where you were before. I believe that will be a good idea, don't you, Mr. Shoemaker?

MR. DUDLEY SHOEMAKER:—I suggested that in the meeting of the committee yesterday. We thought we could follow this thing through at regular intervals after this meeting, addressing all foundries that answered our letters, asking them whether or

not they had tried out the standard design, and if so what results had been obtained, what troubles they had had and what suggestions they had to make, if any. We expect to keep this thing a live issue and go through with other features of steel foundry practice as well as the nozzle, but this is the start of the standardization movement and it rests with the members of the Association whether or not it is going to be a success.

MR. A. W. GREGG:—I would like to add a little to what Mr. Ploehn said. I think it is up to the members of the Association to support the committee in this step. I think we have a multiplicity of designs, most of which are just sentimental ideas, and the only thing for us to do is to stick to one design. Let's have something that is standard. I think this committee is deserving of great praise for the way they carried this out. I am very much in favor of seeing the committee continue their work and include perhaps the stopper head and sleeves. There are so many things they can take up and standardize that it will be of immense benefit to all steel foundrymen. We all have our own designs and probably if we all had the same design we would be doing a great deal better than now. How are we going to get these nozzles?

MR. DUDLEY SHOEMAKER:—The committee will send to all makers of nozzles in this country prints showing the standard design decided on by the American Foundrymen's Association and asking them to prepare them in anticipation of orders, which of course they won't do until they get the orders. It is for the members of the Association to place their orders.

MR. A. W. GREGG:—If we notify our men that we want the American Foundrymen's Association standard design, they will know what we mean?

MR. DUDLEY SHOEMAKER:—Yes, your manufacturer will know. In addition to that, you will have a print to send with your order if you care to take one. You can have as many prints as you want simply by sending a letter and asking for them. We will supply the members of the Association with all the blue prints they want showing the standard design.

MR. W. A. JANSSEN:—A thought that occurred to me is this; some of these steel foundrymen show a manifestation of

being willing to co-operate in the adoption of these standard designs. They may have some difficulty in adapting the particular stopper-head which they are at present using to the new design, and it seems that we will have to give the matter of the stopper-head some consideration or at least make some recommendations to the particular users as to the different types of stopper-heads and their adaptability to the present designs as recommended, because the chances are pretty good that some fellow using this nozzle and his own stopper-head will have some trouble. That recommendation may come from the man in the shop who may have a pet nozzle which he has been using which will not be in accord with the recommended standard. There might be an investigation as to the particular stopper-head which will line up with the recommended standard nozzle.

MR. DUDLEY SHOEMAKER:—I would like to say in that connection that the committee has gone into that subject somewhat and has found that the variation in the working face of the stopper-heads in the various steel foundries is not nearly as great as that of the nozzles. The Dalzel and Dixon people have several face radii which they adhere to even though the inside is changed for the various foundries. There is some question how much difference that makes. Obviously we cannot use small, pointed stopper-heads with a wide, round-faced nozzle, but there is not nearly as wide a variation in the manufacture of the stopper-head as there is in the manufacture of the nozzle.

THE CHAIRMAN:—Are there any further remarks? It is obvious, I think, to all of us, that this committee should be continued and it will not be necessary to make a formal motion to that effect.

ABRASIVES

By Clarence Hawke, Niagara Falls, N. Y.

When we consider the importance of the part played by abrasives and abrasive tools in practically every branch of modern industry, we must wonder at the comparatively small supply of information to be obtained with regard to the general principles governing abrasion. Very little has been written on this important subject, and what knowledge we have has been obtained principally by comparison of results from actual trials made with different materials. In this way it has been possible to deduce certain general laws governing the subject and to establish general rules for the selection of the correct abrasive and best kind of abrasive tool for a particular class of work.

Abrasion is defined as the wearing away of one body by another of harder material. The body of harder material is then known as an abrasive, and this term may be applied in its true sense when referring to certain grinding and polishing materials. In its specific sense, when used in connection with modern artificial abrasives, the term is incorrectly applied, as these materials cut rather than abrade. The term "abrasive" has, however, been given a wider significance, and now includes generally all materials used in the grinding or polishing of other substances.

Natural Abrasives

The first materials used by man as abrasives were found in Nature's store, and were used in their natural state; or in other words, were natural stones. They were employed principally in the production and preservation of edge tools, and to these the term abrasive was certainly correctly applied as the desired results were obtained by a tedious rubbing process between the abrasive and the softer material.

With the advance of knowledge in connection with the applied arts, a more rapid method of abrasion was sought. This was found in the grindstone, which consisted of a block

of natural sandstone hewn into the form of a disc several inches in thickness and provided with a central arbor hole. The stones were mounted on a shaft and rotated slowly by means of a crank fastened on the same shaft. The results obtainable from such an arrangement were far superior to those obtained from any method previously employed. The use of the natural stone wheels was limited very largely by the fact that they did not have the physical properties, strength, etc., required for the effective grinding of metals. Grindstones in their original form, and improved by the power drive, are however, still in use, and a reason for this may be found in the fact that the machinery required to operate them is of the simplest form.

The next important advance was made when certain natural materials possessing abrasive properties, but found in nature in a form unsuitable for use, were crushed to grain of a desired size, mixed with a bonding material and the mass molded into the form of a wheel. Such wheels could be operated at a considerably higher peripheral speed than was possible with the grindstone, and could be made of materials possessing higher abrasive qualities.

Emery

One of the first materials to be used and to become of value for the production of this new and improved form of abrasive tool was emery. Emery is a material many times harder and tougher than the abrasive constituent of sandstone, and is the intimate mechanical admixture of corundum and either hematite or magnetite, both of these latter mentioned minerals being compounds of iron and oxygen. Its value as an abrasive depends upon the amount of corundum present. It is extremely tough, and were it not for the fact that the emery obtainable from nature's store varies considerably in quality, and is often high in impurities, it would be of high value for certain classes of grinding.

As a binding material for these abrasive grains hydraulic cement was first used in an attempt to imitate the natural stone. Such attempts met with only limited success and a

further step was made in the adoption of organic or vegetable substances, such as rosin, sulphur, rubber and shellac, as well as silicate of soda, the three latter materials being successful to a certain extent.

Such bonds, although still found to be of value in the preparation of grinding wheels for special work are not adopted for grinding operations where large quantities of material are to be rapidly removed. Their failure is attributed to the fact that the range of possible grades of binding is limited with such materials. The cost of such materials is also excessive.

As the grinding wheel came to be considered more and more as an indispensable tool in the working of metals, improvements were rapidly made in the method of bonding the abrasive grain. Bonding materials of a semi-abrasive nature were, therefore, substituted in the place of the vegetable bonds previously used. These bonds consisted principally of fusible clays which were mixed with the abrasive grain, the mass formed into the desired shape and then brought to a temperature, sufficiently high to vitrify the mass. The actual amount of abrasion performed by a binding material of this kind in an abrasive tool is believed to be negligible, and in fact has been shown to be productive only of heat. This applies to any binding material, but as a bond is necessary in the preparation of any abrasive wheel composed of an effective abrasive this factor must always be considered and reduced to a minimum. Such a result can be accomplished best with a vitrified bond. Difficulties were experienced with the bonding of emery grains with this type of bond as the impurities contained in the emery, together with the uncertainty of its quality, prevented the attainment of duplicate results.

Along with the development of better methods of bonding abrasive grain, other natural materials were substituted for emery, the principal among these being corundum.

Corundum, which is an aluminum oxide, is found in nature as crystals usually rough and rounded, or massive with nearly rectangular partings. There are many varieties of corundum,

of which the ruby, sapphire and emerald are of the gem class. Corundum is, as has already been stated, the abrasive constituent of emery, in which it is so finely divided that it cannot be separated from the other components.

Next to the diamond, corundum is the hardest known material occurring in nature. In Mohs' scale of hardness corundum is given as 9 compared with the diamond as 10. The hardness of corundum must not be confused with its abrasive efficiency, for although corundums vary but slightly in hardness, there is often a wide variation in the amount of abrasion which they are able to accomplish. The hardness represents the resistance of the corundum to abrasion, or to being scratched by another material, and also its power to scratch another substance. A fragment of corundum entirely free of decomposition may when tested prove to be of a hardness represented by 9, but to have a cutting efficiency that is very much lower than that of another piece whose hardness is just the same. The abrasive efficiency of a mineral or substance depends upon its hardness and fracture. The fracture should be irregular and not along parting planes as is often the case with corundum, in other words, the cutting efficiency depends upon that property which enables it to retain a sharp edge, when crushed into grain. All corundums do not possess this property, and many that exhibit it in the first stages of crushing do not show it in the finer fragments or grain.

As corundum is a product of nature it is often associated with foreign materials which are always softer than the corundum itself. These foreign materials, if present in large quantities, affect the abrasive efficiency very materially. If present in small quantities, the abrasive efficiency of the grain is not affected to any extent, but such impurities are found to be very objectionable when attempts are made to bond such grain into an abrasive wheel by means of a vitrified bond.

In the earth's make-up certain grades of corundum are obtainable which are suitable for abrasives, and by proper selection it is possible to obtain a grade of corundum of a fairly uniform quality, but as parting planes of fracture exist to a large extent in all corundums, its abrasive efficiency is

effectively reduced by this factor. If it were not for this fact corundum would be of exceedingly high value in the grinding of materials possessing toughness.

Before leaving the subject of natural abrasives it is necessary to mention garnet, as this material although of no great importance in the grinding of metals, has been found to fill an important place in the grinding or sanding of wood. For this class of work the garnet grain, after being thoroughly cleaned, is affixed to the surface of either cloth or paper, by means of suitable glues, and is in this way used either in the hand or in the form of belts or discs mechanically driven. As garnet has a low point of fusion it is impossible to bond the material in the form of wheels with anything other than vegetable and silicate of soda bonds. This fact limits its value considerably, although there is a possibility that with a suitable vegetable bond, abrasive wheels might be made with garnet grain to successfully grind the softer materials.

In the scale of hardness, garnet lies between 7 and 8. This particular degree of hardness does not, however, account for its high value in the grinding of wood. The more probable explanation of this peculiar property is found in the fact that a fragment of garnet is seldom solid, but fractured along irregular planes. This property permits the grain to be easily broken down so that sharp cutting edges are always in contact with the fibrous material being ground.

Quartz also is used in a way similar to garnet for the rubbing and sanding of wood, but it is not found to be of such high value for this class of work as garnet. The material is, however, more cheaply procured than garnet and consequently is used considerably.

There are several reasons for the superiority of an artificially produced abrasive material, over those obtained from Nature's store. Principal among these is the possibility of obtaining a far more uniform and pure product by artificial means than can be found in the earth's make-up. The regular cleavage existing in some natural abrasives can be eliminated in the artificial, and the reduction of the abrasive efficiency from this source overcome. Further, artificial abrasives have been produced possessing far greater hardness and abrasive

properties than anything that nature has supplied, with the exception of the diamond. The difficulties caused by the impurity and un-uniformity of the natural abrasives had attracted the attention of many prior to 1891, in which year E. G. Acheson discovered an entirely new substance, silicon carbide, better known under the trade name as carborundum. The discoverer of this new material quickly realized its possibilities in the abrasive field, as it was found to possess a hardness far above that of anything found in nature, with the exception of the diamond.

Silicon Carbide

Silicon carbide is a material composed of one atom each of silicon and carbon. These two elements are driven together by means of the high heat of the electric furnace and the resultant material is found to possess a hardness nearly equal that of the diamond, or from 9.6 to 9.7. In addition to its extreme hardness, silicon carbide possesses the characteristic of sharpness. This characteristic is accounted for by the fact that the crystal has an irregular fracture and always breaks down into fragments with sharp cutting edges. The combination of these two properties, hardness and sharpness, make this material an ideal abrasive for the grinding of cast iron, chilled iron, bronze, brass, granite, marble, etc. Silicon carbide is slightly more brittle than the diamond and to this property may also be attributed its extreme sharpness. Made at a temperature of approximately 2,200 degrees Cent., the grain is not affected by fusion with the proper clays, and vitrified wheels are successfully made. The purity of the final product can be controlled within definite limits, so that uniform results can be obtained.

Silicon carbide is found on the market under several trade names, principal among these being carborundum and crystolon.

Artificial Aluminous Abrasives

In the manufacture of this class of abrasives highly aluminous clays are fused in an electric arc furnace in such a way that the impurities contained in the raw material are reduced, and a product consisting of almost pure aluminum

oxide in crystalline formation is obtained. The crystallization of such material is irregular. This fact, which is common to all artificially produced abrasives, is explained by a consideration of the probable differences in the rate of crystallization of a body produced artificially and by natural means. In the latter case the crystallization has obviously been slow, and consequently well developed crystals are formed along well defined lines. The crystallization of an artificially-produced material is more rapid with the result that the crystals formed are irregular and possess irregular fractures. Abrasives, of the artificial aluminous class, are characteristically tough, fracture into sharp, irregular crystals and do not possess the regular cleavage common to the natural aluminous abrasives. The hardness of such materials lies between 9.1 and 9.2, which is above that of the natural corundum. Artificial aluminous abrasives are successfully bonded by the vitrified process, and have been found to give excellent results in the grinding of steel and metals possessing extreme toughness. Abrasives of this class are found on the market under the trade names of aloxite, alundum, abrasite, adamite and borocarbon.

Scale of Hardness

A more careful consideration of Mohs' scale of hardness to which reference has already been made is necessary at this point for a clearer understanding of the differences existing between abrasives. This scale of hardness was introduced by Mohs, a German mineralogist. Mohs chose ten commonly occurring minerals, each of practically constant hardness. These were arranged in order according to their ability to scratch or abrade one another. For the softer of these materials talc was chosen and given a hardness equal to 1, and placed at the bottom of the scale. Gypsum was found to have the ability to scratch talc, but was not hard enough to scratch calcit. Gypsum was therefore given a hardness equal to 2 on this scale and followed by calcit with a hardness of 3. The other minerals were then placed in position upon this scale according to their ability to scratch other substances, or to be scratched by them. In this scale the diamond was placed at the top and given a hardness equal to 10. Corundum (sapphire variety) was placed

next below it and given a hardness of 9. The topaz followed next in line with a hardness of 8. Here it should be noted that owing to the imperfection of this scale, the actual difference existing between a hardness shown as 9 and one shown as 10 is considerably more than between 9 and 8. This is accounted for by the fact that minerals with a hardness greater than 9 are not common, and because of the experimental difficulties in determining the hardness of such substances. It is, however, generally conceded that the difference 9 to 10 is approximately equal to the difference 1 to 9. Carbide of silicon is therefore probably two or three times harder than the next below it, or those of the class of artificial aluminous abrasives. These in turn are considerably harder than the natural corundum, although their position on the scale is only slightly removed. Mohs' scale of hardness does not give an accurate figure for the hardness of a body, but simply shows its hardness relative to another body.

When choosing the correct abrasive to perform a particular grinding operation it is necessary to carefully consider the properties of the material to be ground. As has already been stated, the hardness of an abrasive is not always the determining factor, for if this were so the hardest would give the best results under each and every condition.

A vital factor to be considered in connection with any grinding operation is the production of heat. The production of a certain amount of heat is common to every grinding operation. This heat can, if produced in excess, work disadvantageously by either burning or drawing the temper of the material being ground, or by causing the grinding tool to fill with the overheated material which it is removing. The production of heat is dependent upon three factors; first, the ultimate strength of the material being ground; second, the rate of removal of stock; and third, the contact area of the grinding tool with the work.

If we attempt to use an abrasive possessing the qualities of extreme hardness and sharpness to grind a material which is tough and of high tensile strength, we find that excessive heat is generated; in other words, the amount of work per-

formed by such an abrasive upon the metal of high tensile strength has been sufficient to produce excessive heating, with the result that the abrasive tool is ruined by filling, or the work burned.

To successfully perform any grinding operation it is of course essential that the abrasive grains used are bound together with a suitable binding material, and that the grade or degree of binding should be adapted to the particular operation. In addition to a correct selection from the great variety of grades made possible in an abrasive tool by a variation of the amount and type of bond used, it is also essential that the abrasive should possess the required properties. For the grinding of hard materials which are of a low ultimate strength, or such materials which are not easily fused, the hardest abrasive is successfully used. When, however, materials of high ultimate strength, or materials which are characteristically tough, such as steel or malleable iron, are to be ground, superior results are obtained from a softer abrasive, such as found in the artificial aluminous class, as the penetration under a fixed or constant pressure would depend to a large extent upon the hardness of the abrasive. Upon the extent of this penetration depends the amount of work done and also the amount of heat generated. Although a deep penetration is permissable in the case of a material of low ultimate strength, or one that is not easily fused, it is liable to produce excessive heating in the case of materials of high ultimate strength.

Another characteristic which is essential to an abrasive for the successful grinding of steel is toughness. This property is possessed in a marked degree by abrasives of the artificial aluminous class, and is responsible to a certain extent for their superiority for the grinding of tough metals, over the harder but less tough abrasive "silicon carbide." This characteristic is obviously essential to the successful grinding of such materials when we consider the necessity of the abrasive grain holding the bite or depth of penetration taken and carrying it across the contact area of the tool with the work. If an abrasive grain is not sufficiently tough to hold such a cut and withstand the strain put upon it by the resistance of the material being

ground, it will fracture too rapidly, or before it has had sufficient time to perform the work required of it. Such a condition would result in an excessive wheel loss without the required removal of material. The slightly softer but tougher artificial aluminous abrasive is favored in this respect in two ways when called upon to grind materials of high tensile strength; first, as the slightly softer material does not penetrate or bite into the material being ground, to the extent of a harder abrasive, the depth of bite and consequently the strain put on the grain is not as great as would be the case with a harder material. Secondly, with superior toughness it is able to hold the cut or bite taken, which in the first place is not as great as would be the case with the less tough, but harder and sharper abrasive.

The necessity of selecting the correct type and grade or amount of bond has already been referred to. For such a selection a knowledge of the actual conditions under which a grinding operation is to be performed is essential. The grade or degree of binding required in an abrasive wheel is governed to a large extent by the amount of dressing action present in the operation. The contact area of the wheel with work, the relative speed between wheel and work, as well as the depth of the cut and the condition of the surface being ground, all tend to control the amount of dressing action produced. These must all be considered in addition to the properties of the material being ground and the final finish required. Other important factors are the application of the abrasive wheel to the work and the construction of the grinding machinery used. If the work is automatically applied to the wheel a far more loosely bonded wheel can be used than is required to grind similar materials applied by hand, as the dressing action in the former case is far less than in the latter. For precision work rigidly built machinery is absolutely imperative to the production of satisfactory results. This factor must receive consideration when selecting the correct abrasive wheel for such work, as vibration increases the dressing action upon the wheel considerably.

In general, the successful bonding of the correctly chosen abrasive grains into the form of an abrasive wheel or tool

depends upon the property of the bond used to break down at the proper rate. This rate should be sufficient to allow each abrasive grain to perform the maximum amount of work possible to such a grain before it is released from the mass of the wheel. It should also be sufficient to prevent the wheel from glazing. In other words, the grade or hardness of the abrasive tool should be sufficient to permit a rate of wearing away which will at all times leave a sharp cutting surface on the abrasive tool and allow for a maximum utilization of the cutting possibilities of each grain of abrasive material. The actual type or characteristic of hardness and toughness possessed by the bonding materials used plays an important part in the success of an abrasive wheel. The size of the grit selected for a particular grinding proposition is also a matter of vital importance, as upon this factor will depend to a large extent the rate of removal of material, and consequently the heat developed. The final finish depends also upon this factor, and is often a limiting condition.

It is a general practice among abrasive wheel manufacturers to signify the size of the abrasive grain used by adopting numerals representing the number of the screen through which the grit designated has passed. These screens are numbered in accordance with the number of meshes per linear inch, so that a grit or grain designated as No. 24 would imply that the grit had passed through a No. 24 mesh screen, but would not pass through the next finer mesh used in the system.

In the class of artificially produced aluminous abrasives and carborundum we have a combination of characteristics required by abrasives for the successful grinding of metals of the hardest as well as the softest varieties, and those of the lowest as well as the highest tensile strength. By properly binding such materials to suit the actual conditions found in any grinding operation, results have been obtained which have been shown to be far superior to anything obtained by the use of natural abrasives, both as regards rapidity of production and economical working.

With such materials it has been possible to successfully perform grinding operations beyond the limits of possibility with natural abrasives.

Although the choice of the proper grinding wheel for the general line of grinding operations common to the foundry does not require the extreme care necessary for a successful selection in the case of fine or precision grinding; nevertheless, careful consideration should be given to every detail of each operation.

With information to the effect that a certain wheel to run at a normal speed of 5,000 surface feet is required to grind cast iron, it is not always possible for a wheel manufacturer to supply the right wheel. The actual grade of the cast iron used should be specified in such a case. Stove castings for instance are made of a mix to produce a fine grain, even iron; machinery castings are often made of a similar grade. In a so-called job foundry the grade of metal will show greater variation and as a rule run coarser and harder. Other conditions being equal, it is found to be possible to use a harder wheel to grind fine soft iron than is required for the harder, coarser metal, with equally rapid results.

The size and form of the castings, together with the amount of material to be removed, will also play an important part in the grading of such wheels.

Grinding Castings

As a general rule it is found that a wheel composed of carborundum of a grit represented by from 16 to 24 and bonded with a high or hard bond, will give excellent results for the grinding of cast iron. The coarser grit wheel is generally used on the heavier castings where large amounts of material are to be removed; the finer grit wheels for the smaller and lighter castings.

When malleable iron castings are to be ground the details of each operation should be more carefully considered than in the case of cast iron, as actual experiments have shown that the quality and texture of malleable irons met with in different foundries vary considerably. As in the case of cast

iron, coarser wheels are used on the heavier castings and finer wheels on the smaller. With this material, as with steel, abrasives of the artificial aluminous class have been shown to give superior results to carbide of silicon for reasons already stated. On heavy castings grits as coarse as 8 and 10 are found to give the best results when bonded with a hard and tough bond. In some foundries it is a practice to grind or finish small malleable castings in the hard before they are annealed, and for this class of work the harder abrasive, silicon carbide, has been found to be superior.

For the grinding of steel it is generally found that a harder bonded wheel is required than for malleables. It is also found that a considerably harder wheel is required for use on a swing frame grinder than is required for a stand grinder operation.

For the grinding of the general line of castings found in a brass foundry such extreme care in selection of a grinding wheel is not necessary, as the same wheel, properly selected, will take care of all kinds of such grinding, with the exception of perhaps straight aluminum or copper. For this class of work a softer wheel is essential.

As a general rule the grinding machinery used in foundries does not receive the attention which is necessary to the production of economical results. A loose bearing, or vibration in the spindle of a grinding machine is very liable to cause uneven wearing on the wheel. This uneven wearing of an abrasive wheel is often attributed to faults in the bonding, or unevenness in the wheel, whereas the actual source of the trouble lies in the grinding machine and not in the grinding wheel. Vibration in a machine spindle will reduce very effectively the life of a wheel, even though uneven wearing does not take place.

The peripheral speed of an abrasive wheel should also be kept as nearly constant as possible and the machine speed changed to produce this effect as the wheel is reduced in diameter by wear. The actual speed at which the wheel is operated should be as specified on the tags supplied with the wheels by the manufacturers.

It is also very commonly found that the use of the dresser is abused in foundry practice. Wheel operators are often allowed to dress their own wheels, and if the amount of material removed by such means was carefully checked up it would be found that more of the wheel was lost from this source than by the actual grinding operation. By placing the care of abrasive wheels under a competent man it has been shown in numbers of cases that an increase in the life of an abrasive wheel used as high as 150 per cent can be obtained. If it is absolutely necessary to frequently dress a wheel it is obvious that the wheel is not suited for the particular operation, as a correctly graded wheel should not require frequent use of the dresser.

Another important feature is the necessity of providing sufficient power to a grinding machine to enable the wheel to retain its constant speed and not slack up as excessive pressure is applied on the work.

Finally, as abrasive tools and abrasives in general have now reached such a high degree of perfection, it is necessary that the same amount of care should be exercised in their choice and preservation as is commonly given to other precision tools.

Discussion

MR. DUDLEY SHOEMAKER:—I would like to ask whether the wear of the wheel represents the breaking of the grains or the pulling of the grains from the bonding material?

MR. CLARENCE HAWKE:—Wheel wear can take place in two ways.

MR. DUDLEY SHOEMAKER:—Very much is said about the hardness of the various kinds of grains. They are all very hard. It is our experience that often wheels wear down in a few hours because they are not properly bonded. The grains do not break at all, they just pull out of the bond.

MR. CLARENCE HAWKE:—I should have mentioned this point which is included in my paper. A correctly bonded wheel should break down at a rate which will permit the wheel.

at all times, to retain a sharp surface or cutting edge and at the same time show a maximum utilization of the cutting powers of each grain. Now it may be found that a wheel is bonded too soft for a particular grinding operation and will consequently break down faster than is required. Then, again you may have two wheels of exactly the same hardness which may be correct for the work, one made of an abrasive suitable for the work and the other of an abrasive which is not, and it will be found that the one will break down or wear away faster than the other, not because the bond is breaking away or releasing the grain too fast, but because the grain itself is breaking away. It has been found, for instance, in trying to use carbide of silicon for the grinding of certain classes of malleable iron that a wheel of a grade, say represented by "H", will give equal if not a longer life than one which is of a harder bond, and the only explanation which can be accepted for this fact is that the grains of carbide of silicon themselves are rapidly breaking away; so that wheel wear can be attributed to two sources, the breaking down of the bond and the breaking of the abrasive grain.

MR. DUDLEY SHOEMAKER:—In dressing the wheel, you remove the bond so the grain will stick out?

MR. CLARENCE HAWKE:—To a certain extent; if wheels is picked out from the bond, leaving the wheel more open and free.

MR. DUDLEY SHOEMAKER:—Then a softer wheel cuts much faster?

MR. CLARENCE HAWKE:—To a certain extent, if wheels are too soft they will break down too fast and the life of the wheel will thus be reduced and the desired effect will not be obtained.

MR. DUDLEY SHOEMAKER:—Can you tell how soft wheels are when you buy them?

MR. CLARENCE HAWKE:—If you buy a wheel for a certain grading, they are supposed to be of the grade specified.

MR. DUDLEY SHOEMAKER:—How can you tell how soft they are when you buy them?

MR. CLARENCE HAWKE:—You mean how can the wheel user tell—that's something I don't believe is possible. You can tell from the actual life obtained from the wheel, possibly.

MR. DUDLEY SHOEMAKER:—Of course after you have used up a wheel you can tell how long it lasted. We have been experimenting for three years and haven't found any way to tell yet except by using it.

MR. CLARENCE HAWKE:—The usual way is to test a wheel by hand, but that requires an awful lot of experience. A man cannot do that unless he has been working at it for years and does practically nothing else. You hardly expect to find a man in the employment of the wheel user sufficiently trained to do that.

The Selection of Grinding Wheels For the Foundry

By Carl Frederick Dietz, Worcester, Mass.

There is so great a volume of matter that may well come within the scope of this paper that it is difficult to decide just what data might be used to the best advantage in presenting the subject concretely. It would seem that a correlation of facts gathered together as the result of laboratory and practical investigations covering years in the development of the grinding wheel industry would serve as a basis for discussion and also, it is hoped, as a contribution of some value to the *Transactions* of the American Foundrymen's Association.

The development of the modern grinding wheel has been simultaneous with the development of the modern foundry. It would be quite impossible to conceive of a foundry with the melt running into hundreds of tons, removing the fins and spurs of its castings by means of chisel and file. A grinding wheel is both in one—a massive aggregation of little cutting tools bonded together in such manner that their high speed of rotation provides an opportunity for the rapid and economical removal of large quantities of metal, doing in a few moments what could only be accomplished by endless manual labor with hand tools, if indeed at all.

It required years of patient study of abrasives, bonds, burning conditions and the many other factors entering into its construction to develop this tool, with the result that, while in general appearance the modern article is not unlike that made a quarter of a century ago, it is an advanced product, calling upon the services of skilled engineers from the time the raw material is mined, through the stages of its conversion in electric furnaces into an artificial abrasive of high purity and uniform quality, and its final preparation and bonding into a homogeneous mass wherein the best skill and cunning of the ceramist is called upon to vitrify the bonds to a degree of nicety

hardly attempted even by the makers of the world's finest pottery.

Although the grinding wheel made by the vitrified process has the greatest interest for the foundryman, many other bonding materials are used, notably the organic mixtures employed in the manufacture of elastic or vulcanite wheels, and the salts used in the construction of silicate wheels.

Grinding or snagging of castings must, by the very nature of the operation, be classed as rough work, which fact immediately establishes, in a general manner at least, the type of wheel to be considered, from coarse to medium in grain, and hard in grade.

These characteristics apply to practically all foundry wheels, whether the material to be ground is steel or its alloys, cast or chilled iron, brass, bronze or any other product.

Many Factors Involved

The specific combination of grain and grade as well as the abrasive material itself is controlled by many factors.

Grain and grade are influenced by

1.—Speed of wheel.

2.—Condition of machine, whether massive and rigid or light and shaky.

3.—Contact, large or small, of course with reference to its dressing action upon the wheel.

4.—Method of application, whether floor stand, swing frame or flexible shaft grinder.

5.—Ability of operator, whether trained to consider the wheel a valuable cutting tool or not.

6.—Character of material, hard or soft, high or low tensile strength.

7.—Finish required, whether rough surface as left by a coarse wheel is satisfactory or whether a smooth surface is sought.

The selection of abrasive material is, aside from possible commercial considerations, almost entirely dependent upon the character of the material to be ground.

Wheels are made up in many combinations of grain sizes and a number of grades of hardness. In foundry practice it is found that grain sizes from 8 to 30 include practically all operations while the grades or relative hardnesses vary from P to U or W, with all the intermediate letters designating a certain grade. The alphabet is used to denote grade by employing the beginning of the alphabet to denote soft wheels.

Grain size is measured by the mesh of the screen or number of openings per linear inch over which the ground abrasive is sieved, while grade is a relative measure of hardness and represents the tenacity with which the bond holds the grain particles together. Thus wheels are being made so soft as to enable one to rub the particles away quite readily with the fingers while others are made so hard that specially devised instruments and apparatus is necessary to true or size them.

Abrasives

Until comparatively few years ago little was known of different kinds of abrasives and still less of the characteristics of those most generally used, but greater accuracy together with more active competition and the lack of dependence that could be placed in natural products, either with respect to quantity or quality made it necessary to seek a way out. The result is that today by far the largest proportion of grinding wheels are made of artificial products which are controllable in quantity as well as quality.

We have come to recognize two principle groups of abrasive materials: (1) The aluminous group, which includes emery, corundum, alundum, aloxite, and the like, and (2) the silicon carbide group, embracing crystolon, carborundum and similar products manufactured abroad.

The aluminous group is worthy of a little closer analysis. First emery was the base of all grinding wheels. It is a product mined in Greece and Turkey, but not stable as to quality nor quantity. It is impure, carrying a high iron oxide content and rarely exceeding 60 to 65 per cent in crystalline aluminum oxide. It was quickly recognized that aluminum oxide content in crystalline form represented a direct measure

of abrasive qualities, and a consequent effort was made to find a purer product.

The discovery of India, Carolina and Canadian corundum seemed to fulfill all the hopes in this respect and the materials themselves actually proved their value over emery because of the higher purity, running from 85 to 90 per cent in alumina. The supply, however, was found to be very limited and attention was turned to the possibility of an artificial product with the result, that alundum was discovered in 1900, and since then has made for itself a very enviable record. Alundum is the result of the fusion and simultaneous purification in electric arc furnaces, of the mineral bauxite, a hydrated oxide of alumina, mined for this express purpose in Arkansas. It is purer than either emery or corundum, much more uniform, dependable as a source of abrasive supply and has characteristics which the natural products lack.

One of the principle advantages is that the artificial aluminous abrasives may, by certain treatments during the process of manufacture, be given varying physical characteristics, such as toughness or temper. Thus alundum is made very tough for certain purposes, while also a material of greater brittleness, white alundum, is manufactured for operations where the work of grinding is delicate and particularly sensitive, requiring something more mellow in its action than is needed for snagging castings. The silicon carbide group does not among its members show the wide differentials in quality that the aluminous group does, since the production of this material is wholly dependent upon artificial processes and it must be manufactured under similar conditions with consequently similar results; the variations in the final product are more dependent upon the skill and knowledge of the wheel maker than upon inherent differences in the quality of the silicon carbide material itself. This product is the result of electrically heat-treating proper admixtures of coke and sand principally. Its characteristics are extreme hardness, probably harder than alundum even, more nearly approaching the diamond, and of relatively extreme brittleness, easily breaking

under shock in contrast to alundum, which with great hardness combines the characteristics of toughness.

We have then to consider the abrasive materials themselves as classified and, from purely the academic side of the problem, the artificial products are being recognized more and more as superior to the natural.

A simple illustration of what a modern grinding wheel is

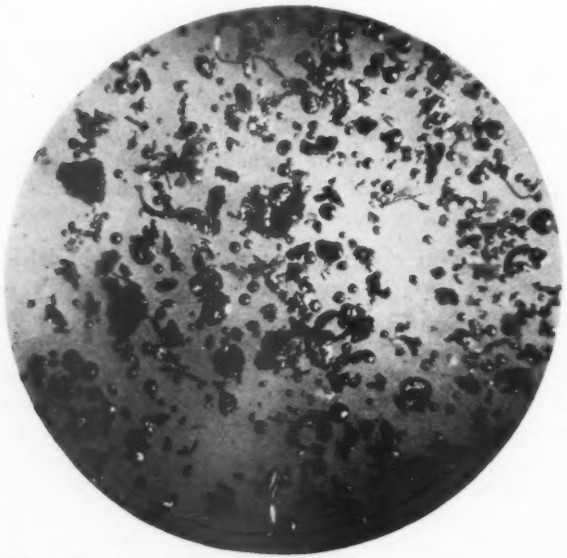


FIG. 1—GRAINS OF METAL REMOVED BY A DULL WHEEL

as compared to the emery may be had when studying the action of the wheels by a comparison of the chips produced.

Figs. 1 and 2 clearly show the comparative results and constitute an important consideration in the selection of wheels. The proper grinding wheel to meet the requirements must be a scientifically developed cutting tool. Its action when at work is similar to that of a steel milling cutter. On the face of the wheel are millions of cutting teeth at work every minute, and although these teeth are not as long nor as strong as the teeth

of a steel cutter and cannot cut as deep, they are capable of working at a much greater speed. Each little cutting tooth, which in substance is a grain of abrasive material, cuts off a chip at each revolution. The chips resemble in shape and character the chips cut off by a milling cutter. Each grain on the face of the wheel continues to work until it is worn away by being fractured and finally consumed.

FIG. 2—GRAINS REMOVED BY A MODERN, PROPERLY MADE GRINDING WHEEL

Before the advent of these modern electric furnace abrasives, grinding was looked upon as a slow, tedious and expensive operation. Webster's definition of the expression "grinding" gives the impression of slowness and defines "abrasion" as the act of wearing or rubbing away. "The wearing away by friction, as the abrasion of a coin."

In Fig. 1, the results of the old-fashioned abrasion described by Webster as "grinding to powder" or "wearing away by

friction", is clearly shown. Each little grain of abrasive material on the face of a grinding wheel cuts off a chip when in contact with a piece of metal at each revolution, its action depending on its nature. In Fig. 2 the chips resulting from a wheel suited to the work are reproduced

The chips in Fig. 1 contain many little globules showing the effect of great heat when grinding, while those in Fig. 2 resemble in every respect the chips cut off by a steel milling cutter.

There is a vast difference between the old-fashioned "abrasion to powder" and the present method of reducing stock

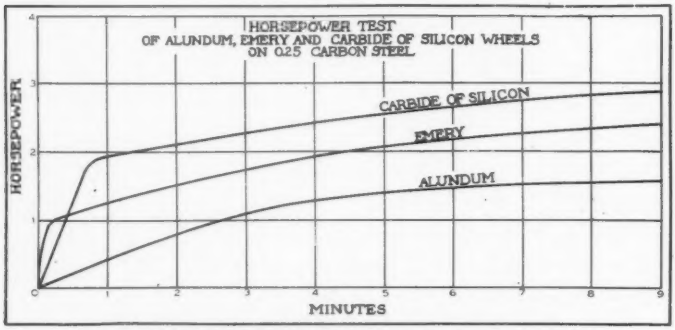


FIG. 3—HORSEPOWER TEST OF VARIOUS KINDS OF GRINDING WHEELS

by cutting off chips. In some cases, there are as many as two billion cutting points at work each minute: eight hundred million per minute is not uncommon and four hundred million per minute is very common.

The first thought that a general classification of abrasives might be established as a guide to proper selection dependent upon the kind of material ground was obtained from competitive trials. An assimilation of this fact, however, was slow in coming, partly because of a lack of complete understanding and partly because no one manufacturer had a variety of abrasives suited to the different classes of metals and the perhaps quite natural tendency to cling to the old thought that

abrasive is abrasive, and if good for one material should be equally so for all.

Later investigation has proved otherwise and disabused the minds of those directly connected with this work that different materials may require a quite different kind of abrasive when low cost is a factor to be considered.

It had been found that on all classes of steel from the poorer to the highest grade alloy steels, the aluminous abrasive alundum was far superior to emery, corundum or carbide of silicon, while on materials of a less tough nature, such as cast or chilled iron, brass, bronze, etc., silicon-carbide gave the better

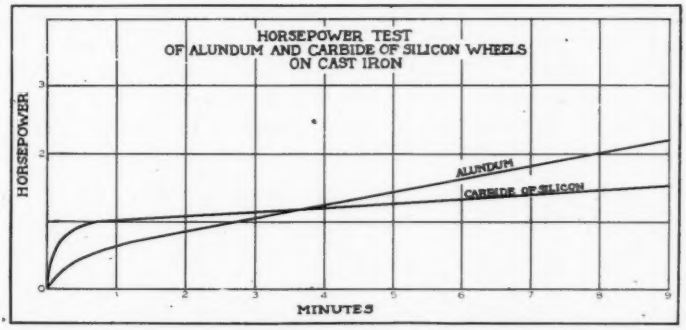


FIG. 4—HORSEPOWER TEST OF ALUNDUM AND CARBIDE OF SILICON WHEELS ON CAST IRON

results. This leads to a general classification of materials and prompts one to seek the particular characteristic common to all which, varying quantitatively, might be the key to an understanding.

All the factors were eliminated as not directly bearing on the subject except tensile strength. This one physical characteristic permits of a general classification from which certain tenable conclusions may be drawn; however, it must be said that this rule, like others, has its marked exceptions.

Hence a series of investigations was made which appear decidedly enlightening and seem to explain some points that had heretofore become accepted facts but only vaguely understood.

Fig. 3 shows curves developed from tests made on a motor-driven Norton cylindrical grinding machine equipped with all the necessary instruments to give the minutest data relative to power, speed, etc. The test was made on 0.25 per cent carbon machinery steel. An analysis of these curves shows that alundum is the most efficient abrasive for this work. The reason for alundum showing a higher efficiency in point of power consumption than emery is due to its greater degree of purity, while the fact that carbide of silicon, the hardest and sharpest abrasive, falls below either of the aluminous abrasives, may not be so easily understood. This is because of its decidedly different physical characteristics, it being thought that because of its comparative brittleness, the grain will not penetrate a metal of high tensile strength, but will break off.

The emery wheel, being composed of a somewhat softer cutting material, on account of the impurities in the grain, also loses its cutting teeth when grinding this tough steel, although not as quickly as carbide of silicon.

Efficiency of Alundum and Carbide of Silicon

Fig. 4 shows the relative efficiency of alundum and carbide of silicon on cast iron. Here the alundum wheel is superior to the carbide of silicon up to a certain period, but after passing this .point the carbide of silicon becomes more effective. The explanation is that the carbide of silicon grain is just tough enough to withstand the comparatively light work it has to do in cutting metals of low tensile strength. The grain of alundum in this case is perhaps a little too tough. It stands up until the grain is too dull, rubbing instead of cutting, requiring more power, and causing much heat which in turn converts the chips into globules.

Fig. 5 shows the relative efficiency of the abrasives in question and may be of assistance in determining the kind of abrasive to be used. It shows that carbide of silicon is most efficient on materials low in tensile strength, such as cast iron, phosphor-bronze, brass, granite, etc., while alundum has its greatest efficiency on steel, malleable iron, etc.

The theory of classification on the basis of tensile strength seems well supported and the general similarity of the curves

representing emery, corundum and alundum (ranged as one would expect them to be based upon their relative purities in aluminum oxide) is particularly noteworthy.

The entirely different characteristic of crystolon or silicon carbide is shown by the curve representing its work. At approximately 50,000 pounds tensile strength, the silicon carbide crosses the aluminus group curves. This corresponds with practical findings that on malleable iron it is often difficult if, indeed, not impossible to decide which is the better abrasive without a careful investigation being instituted. It is noteworthy also that on practically all materials other than metal, silicon carbide is the most effective; this includes granite, marble, concrete, horn, rubber, cork, leather, bone, pearl, etc.

A General Rule

In the selection of abrasive material for foundry snagging, therefore, a general guide (not infallible) may be found in the above considerations. The selection of grain and grade is quite a different matter, however. We have to consider carefully that the life and productivity of a wheel made of a given abrasive material is directly measured by both the grain size and the strength with which the grains are held together. The latter factor is dependent upon the bond both in point of quantity and character.

The function of this bond is not only to hold the cutting particles of the wheel together and to give the wheel the proper factor of safety at the speed it is to be run, but it must also be possible to vary its strength to fit the work it is called upon to do. We often hear the operator say that the wheel is too hard or too soft. He means that the bond retains the cutting teeth so long that they become dulled, and this wheel is inefficient; or, in the case of a soft wheel, the bond is not strong enough to hold the cutting teeth and they are pulled out of the wheel before they have done the work expected.

The bond to be used for any given operation depends upon several factors:

1.—The wheel and work speeds should be considered, the latter in case the grinding is done by machine and not merely

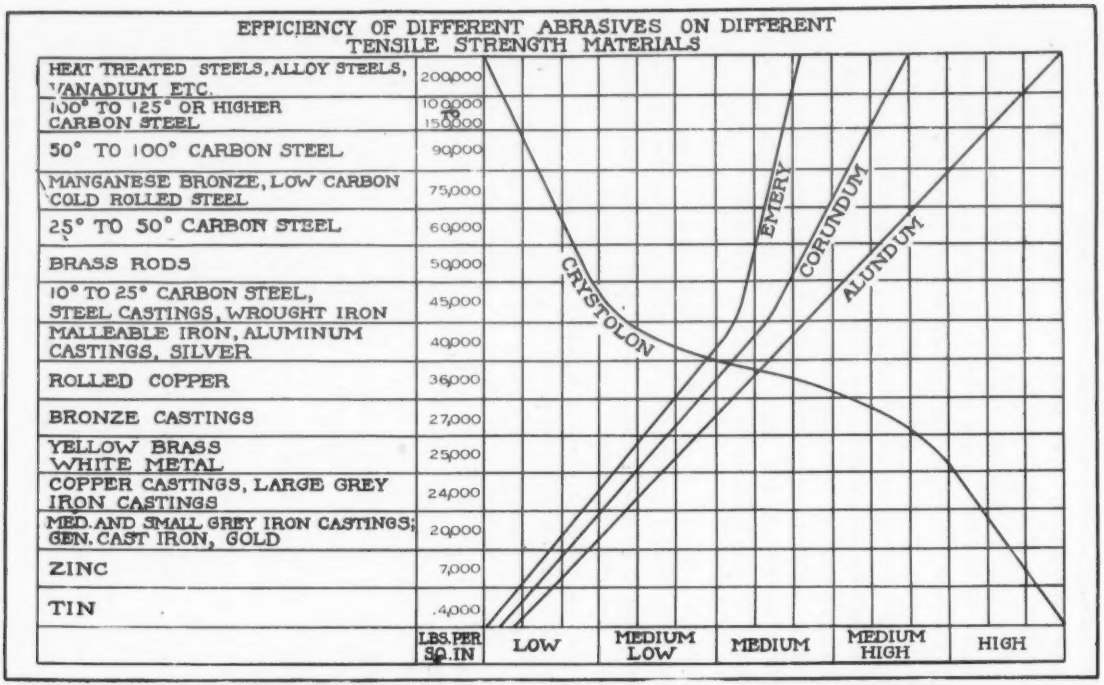


FIG. 5—EFFICIENCY OF VARIOUS ABRASIVES ON DIFFERENT MATERIALS

by hand application. The speed of the wheel has a most important bearing upon its action in point of hardness. A wheel traveling at 5,000 surface feet does not have the resistance that it would have if it were rotating at 6,000 surface feet, hence the consideration of the speed at which wheels are operated must of necessity influence the grade selection. The falling off in surface speed as the wheel wears down is also an important consideration and will be more fully touched upon.

If the work is mounted as in a cylindrical grinding machine or lathe or on the table of a boring mill, revolving against the cut of the wheel, the speed of the work obviously affects the lasting qualities of the wheel and generally it is a fact that as the higher the work speed, all other conditions being equal, the harder must be the wheel.

2.—The condition of the machine, whether it be a floor stand, swing frame or flexible shaft machine, is important, since worn bearings, or an ill-fitting shaft, permit the wheel to jump and pound, thus breaking down the structure without effective work resulting. The rigidity of the machine has an equally important bearing since it is obvious that a light springy structure may be as bad a wheel consumer as loose bearings in a massive construction.

3.—Contact is likewise a necessary consideration, since obviously sharp and narrow fins, sprues or gates have a natural dressing action and must be met with a correspondingly harder product, while if the contact is wide and comparatively smooth the wheel must be softer to permit of the cutting particles taking hold. If too hard a wheel under such conditions is used, it will soon be found that the cutting teeth get dull and glaze, the wheel requiring dressing which results, of course, in waste.

4.—The method of application, whether gentle or abusive, is a factor as well. In some cases heavy castings are swung against the wheel face with such force as to make the entire apparatus vibrate. Extremely hard wheels under such conditions are paramount, while with small hand-applied castings, the gentler application requires a softer wheel to actually perform the work.

5.—The ability of the operator should be considered. Herein lies a very elusive factor, in that wherever the human element is introduced, variables must necessarily be concomitant therewith. It is not uncommon to find two operators, working side by side under as nearly identical conditions as it is possible to produce, obtaining vastly different results in both output and life of the same grinding wheels, and they consistently continue to remain in the same relative positions unless the inferior worker is taught some of the very simple principles instinctively picked up by his neighbor.

The Work Should be Properly Applied to the Wheel

The method of applying castings, so that by the very work the wheel is performing, it is kept sharp and free cutting, is a matter to which every grinding room foreman should give attention. Permitting a wheel to become dull and consequently require dressing is wasteful, both in that valuable wheel material is thrown away and the operator's time lost. If the casting is such that no matter how it is applied, frequent dressing must be resorted to, it is a reasonably safe assumption that the wheel is not the proper one for the job.

In many instances in the case of both large and small castings, it has by education been possible to entirely discard the dresser, resulting in greater production and longer life for a given wheel. In many kinds of grinding a certain reasonable amount of dressing is necessary just as a milling cutter requires sharpening in machine work, but in snagging work a combination of grain and grade should be used that will permit of a sharp wheel face being maintained without recourse to the wasteful dressing tool.

6.—Character of material, whether hard or soft, tough or brittle, goes hand in hand with the question of contact and determines both the grain size as well as the grade. In some materials it is necessary to experiment with both kinds of abrasives before the best is determined, while with others it is practically a foregone conclusion which kind will prove best. Generally, brittleness in abrasive material does not go with high tensile strength and hard irons call usually for the silicon

carbide, whereas tough materials require the aluminous abrasive. Hard materials, if contact is wide and little dressing action takes place, will be best served with a wheel of somewhat softer grade than is required for very tough steels. The various factors already described must be considered collectively and no definite rules can be set down to follow.

7.—The finish desired is practically a measure of the grain size necessary. For rough, heavy castings, where the essential feature is to remove the stock in the shortest possible time, and finish is secondary, an aggregation of coarse grains, each plowing out a comparatively heavy chip, may be used, while on the other hand small castings such as many machine parts, ornamental fixtures, or parts that are to be plated, must be provided with a fairly smooth surface requiring in turn grains of finer mesh, down to 24, 30 or 36, each of which manifestly cuts less deep than a 10, 12 or 14-mesh grain, leaving consequently shallower furrows in the finished surface.

Sight must not be lost of the fact that grain size has a certain influence on the action of a wheel with respect to its hardness or wearing qualities. Because of this, certain differentiations may be employed to overcome possible difficulties, by altering the grain size without necessarily altering the grade. For example, a 16-grade U wheel may be found a little too hard. It is feasible and practical in many instances to then change to a 14-grade U, which gives the wheel a slightly more open structure and under the same conditions will be found to act a little softer. Thus frequently advantage is taken of this fact and judicious substitutions often assist in bettering the conditions.

Mention has already been made of the influence of speed on both the cutting action and life of a wheel. It is worthy of a little deeper consideration.

At times it is reported that a wheel is below some other wheel in point of output and life, when an investigation may show that comparison has been made between wheels of different diameters, and while the revolutions per minute may be alike the peripheral speed is quite different. A maintenance of

proper speed means much to the productive capabilities of a wheel.

An 18-inch wheel at 1,280 revolutions per minute moves with a peripheral speed of 6,000 feet. At 15 inches in diameter and the same revolutions per minute the surface speed is about 5,000, while at 12 inches it has dropped to 4,000.

The peripheral velocity at all times varies directly as the diameter under constant speeds. That is, the velocity at which the face of the wheel travels, when the number of revolutions per minute remains constant, grows less as the diameter decreases; hence when the wheel is only five-sixths of its original size, the surface speed will be only five-sixths of that when the wheel was mounted, and when the diameter is down to two-thirds the original, the surface velocity will also be but two-thirds of the original.

The Work Done by a Grinding Wheel

When a grinding wheel acts upon a piece of metal forced against its face, it is called upon to do work, or expend energy. This energy is supplied by the power given to the spindle and is taken up largely by the resistance the work offers to the abrasive particles acting as cutters on the face of the wheel. These particles cut loose a given piece of metal which leaves the point of contact at a line tangential to the wheel. At the same time, the resistance of the metal causes the abrasive particle to be worn down and broken off, or if the cutting edge of the particle in question has become very dull, the resistance of the metal may tear it out of its setting, exposing a fresh, sharp particle, which can do the work.

All this requires energy, which is stored in each particle of abrasive grain and capable of performing work. This energy factor is proportional to the square of the velocity with which the body travels, hence the power to do work falls off more rapidly than merely the difference between surface speeds at varying diameters. It is not so difficult then to understand why the complaint is frequently made that a wheel has diminished in productiveness toward the center and appears soft.

XUM

Consider for a moment Fig. 6. The cutting teeth when in contact with the work at *A* have a certain energy stored up in them, due to their mass and speed of travel. This energy is used in part to cut chips, and since this energy, as shown by the mathematical expression in the diagram, is proportional to the square of the velocity, it falls off as the diameters shrink to 15 and 12 inches in the proportions of 36 to 25 to 16. These latter figures represent the squares of the peripheral speed. In other words, when the diameter of the wheel has become 15 inches, the energy stored up in the cutting tooth is but 70 per cent

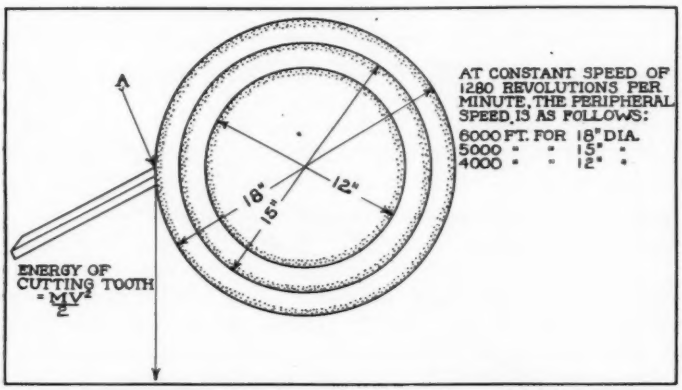

A
18"
15"
12"
AT CONSTANT SPEED OF 1280 REVOLUTIONS PER MINUTE, THE PERIPHERAL SPEED IS AS FOLLOWS:
6000 FT. FOR 18" DIA.
5000 " " 15" "
4000 " " 12" "
ENERGY OF CUTTING TOOTH = MV²/2

FIG. 6—DIAGRAM SHOWING VARIATIONS IN PERIPHERAL SPEED AND ENERGY

of that at 18 inches, and when 12-inch diameter is reached, the energy is less than half of that at 18 inches, or but 44.5 per cent of the original.

The grain has therefore less energy stored up within itself with which to meet the same resistance and the particles lose in cutting quality and are more readily torn bodily out of their setting. The wheel, therefore, loses in productive power as the speed of its cutting tooth is reduced, acting softer and forming the basis of complaints because of a lack of appreciation on the part of the user of the importance of speed. The logical method for meeting this difficulty is to either steadily

increase the speed of rotation as the diameter wears, or from time to time to transfer wheels to higher speed machines.

It must not be assumed, however, that the productive capacity of a wheel when worn down to 12 inches will be the same as at 18 inches, even if the peripheral speed is maintained constant. Manifestly each cutting particle is called upon to act as much oftener as the revolutions are increased as follows:

Diameter.	Surface feet.	R. P. M.
18	6,000	1,280
15	6,000	1,520
12	6,000	1,920

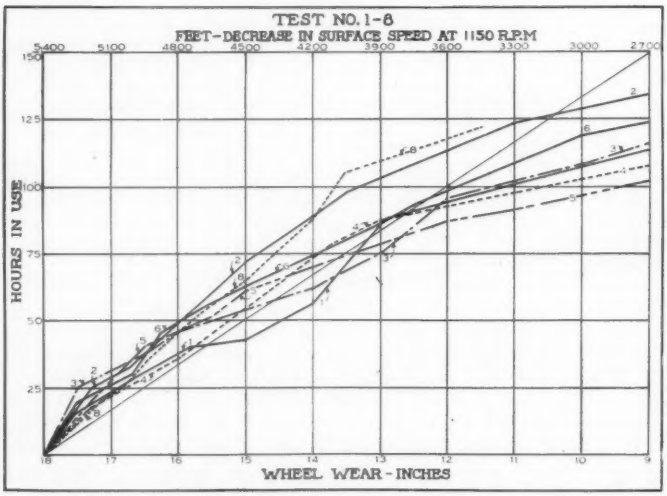


FIG. 7—WHEEL WEAR CURVES

Hence the cutting tooth when at 12-inch diameter is called upon to perform nearly 55 per cent more cuts if no greater wear is had. It is not likely that the grain will stand up to this, but it will approach it and the greater holding power of the bond at the higher speed will hold even a comparatively dull grain with sufficient tenacity to plow out a chip which might otherwise be met by a resistance sufficient to tear out the

grain and leave the partial work to be completed by the next grain in contact.

The relation of life of wheel to speed is perhaps more clearly indicated in Fig. 7, representing the results of some tests recently reported upon. These curves show the rate at which the life of the wheel decreases as the peripheral speed drops off. The continuous straight line is for a wheel lasting 150 hours in wearing uniformly from 18 inches to 9 inches in diameter. Surface speed to start was 5,400 feet and revolutions per minute being maintained constant the surface feet dropped to 2,700 feet at 9 inches diameter.

At 5,400 surface feet and full diameter the wheels start off at a 200 to 250-hour pace, but the effect of a falling off in speed is almost immediately detected and instead of obtaining even 200 hours of wheel life, the ultimate result is considerably less than 150. Had these wheels been speeded up again at 15-inch diameter and 12-inch, they undoubtedly would have shown more nearly straight lines and their life proportionately increased. The inclination of the lines to the horizontal measures directly the rapidity of wear and the more acute this angle, the more rapid the loss of wheel diameter.

Increased production is unquestionably to be expected from an increase in speed, because of, first, the greater energy and consequent cutting ability of the grain particles; second, the more frequent cuts of each grain per unit of time; and third, the harder action of the wheel, or better, the greater holding power of the bond.

It must be borne in mind, however, that a wheel selected to do a certain piece of work at say 5,000 initial surface feet, will not, if already at the limit of hardness, necessarily operate satisfactorily at 6,000 surface feet per minute. A change in grain and grade combination may be necessary and the higher speeds should be employed only when the machines are in good condition, and provided with proper protection hoods.

The results of these plottings clearly indicate that a wheel should, in so far as is practical, be maintained at a uniform surface speed, either by variable speed motor control, cone pulley shift, or as is now being done in many shops, trans-

ferring the wheel from one stand to another every two or three inches of its wear. Thus periodically a higher number of revolutions are provided to bring the surface speed back to practically that at which the new wheel started. This will be found to bring about a condition of economy little appreciated by those who have not had occasion to try it.

It would not be practicable to outline the many hundreds of operations for which grinding wheels are required, but the following table may serve as a guide and has been prepared on the basis of wide general experience with wheels made of alundum and crystolon. Within the ranges given it is likely that a satisfactory combination of abrasive, grain and grade for any given grinding operations will be found.

Kind of Work.	Grain.	Abrasive.	Grade.
Large Steel Castings.....	10 to 14	Alun. Vit.	S and harder
Small Steel Castings.....	20 to 30	" "	P to S
Large Mall. Iron Castings..	14 to 20	" "	Q to U
Small Mall. Iron Castings...	20 to 30	" "	P to S
Large Cast Iron Castings..	16 to 24	Crys. Vit.	Q to U
Small Cast Iron Castings...	24 to 36	" "	P to U
For Machining Alloy Steel Castings on Lathe, Boring Mill and Shaper Types of Machines	14 to 20	Alun. Vit.	M to Q
Brass and bronze castings...	24 to 36	Crys. Vit.	O to Q
Aluminum Castings.....	30 to 36	Alun. Crys. } Elas.	4 to 5

From this table it will be noted that the aluminous abrasive is generally specified for the high tensile strength material while crystolon is set against the low. To this, however, as well as other rules, exceptions are to be recorded. For example, while malleable iron is given as an aluminous abrasive material, the unannealed product is generally found to be better served by the more brittle silicon carbide abrasive. Aluminum is another curious exception, in that its peculiar physical characteristics make it necessary to have the interstitial space between the grains practically filled, as in an elastic wheel. Also the fact may be pointed out that both kinds of abrasives under discussion may be used. Fig. 5 shows the position of malleable iron and aluminum at about the crossing points of the efficiency curves, and only slight local conditions may

influence the selection of abrasive in such a way that apparently the same general class of material in two plants is ground most effectively with crystolon in one and alundum in the other.

The measure of value of a wheel in any industry, especially where it constitutes an important tool in preparing the product for the market, is unfortunately, in many instances, not thoroughly appreciated. Wheel value rating based on life alone, that is the number of hours it is in service, is still frequently applied, but manifestly the true value of a wheel cannot be gaged by this factor alone with any degree of dependability. One wheel may last longer than another but not turn out as much work per hour as will a freer cutting wheel of shorter life, while at the same time total production may be the same. Obviously the wheel that has the more tonnage per unit of time to its credit must be the more economical of the two since the capacity per unit investment of wheel, machine and space is increased. Strange to say this fact is lost sight of frequently, but happily the operation of grinding wheels is commanding the more careful consideration that its importance in the industries warrants, and a better understanding of the relationships which output per unit of time, life and operator's wages bear to each other is gradually but surely being developed. Without a consideration of these three factors collectively, one cannot be certain that the best wheel is being employed.

Discussion

MR. STANLEY G. FLAGG III:—I would like to ask Mr. Dietz in reference to the grinding of small castings, if the tests were made after leaving or before leaving the hard iron?

MR. C. F. DIETZ:—They were all taken from annealed castings.

MR. STANLEY G. FLAGG III:—Have you any results on hard iron?

MR. C. F. DIETZ:—Sometimes we are put to it to find whether an alundum wheel or a silicon-carbide wheel is best,

but the difference in price frequently controls; that is, the increased efficiency of one over the other is not sufficient to make the difference in price ineffective. That is probably the most difficult thing we have to decide, the selection of grinding wheels for hard iron in malleable foundries.

STANLEY G. FLAGG III:—Do you think it is any cheaper to grind small gates before or after annealing?

MR. C. F. DIETZ:—I think on small gates it is probably cheaper to grind before annealing. I would not want to make that a general blanket statement, but I think generally it will be found so. You mean on very small gates?

MR. STANLEY G. FLAGG III:—Yes.

MR. C. F. DIETZ:—Yes, before annealing.

MR. BOSTICK:—At what degree of heat would you consider a wheel dangerous to operate? How hot would it be before it would be apt to break, in your opinion?

MR. C. F. DIETZ:—We tried to determine that at one time. Wheels break, not because they are heated uniformly throughout their mass, but because they become heated on their periphery, and cause the outside bands of the wheel to expand away from the core; that is a typical condition when a wheel is broken due to heat. Usually it breaks right square through the center, a diametric break. We endeavored by winding wire around the periphery of a wheel and passing an electric current through it to make a pyrometer and determine what temperature would be safe to use, but the results were so erratic that we could not reach any conclusions. It depends on the size of the grain particles, whether the wheel is dense or open and the character of the bond. It is impossible to determine the temperature by any definite rules. I know of wheels successfully operated, so hot that if water was dropped on them, it would sizzle, and the heat has not had any breakage effect. Others that I know of have been warm to the touch and yet they would break; it is largely due to the materials used.

Refractories—Their Selection and Use in The Foundry

By Walter H. Kelley, Pittsburgh.

Your program committee has asked me to contribute a paper on the selection of refractory materials for the lining of various furnaces and ovens in connection with the foundry industry. While I realize this question is by no means one of your most important problems, I believe you are all interested in any problem, the adequate solution of which will reduce costs. In order to intelligently consider the various refractories commercially available, we must first enumerate them briefly as follows: Fire clay brick and silica brick; bauxite brick; chrome brick and magnesia brick. Of the foregoing we are all familiar with fire clay brick, which, of course, enjoys by far the widest use.

Silica brick are made solely from a ganister or quartz rock, most carefully selected to secure only the material low in impurities. This ganister occurs usually in floes or fields on the mountain side, where, through ages past the elements have split and torn the parent ledge, leaving the fragments covering the slope from three or four to even 20 feet in depth. Silica brick are made from this crushed ganister rock with 2 per cent of lime added in the form of milk of lime, while the stone is being ground in the wet pan. Analysis of the burned brick will show an average of 1.75 per cent lime. A typical analysis is given as follows:

	Per Cent
SiO_2	96.25
Al_2O_3	.85
Fe_2O_3	.82
CaO	1.80
MgO	.15
K_2O Na_2O	.40
	100.27

Bauxite brick, as the name indicates, are made from bauxite ore, a hydrous oxide of alumina containing about 30

per cent water, practically all of which is water of crystallization. A fairly representative analysis is given in the second table below. It is mined in this country in Georgia, Arkansas, Alabama and Tennessee, Arkansas being by far the largest producer. Large quantities are also imported from France. It is hardly necessary to say that the bulk of these various ores is consumed in the production of metallic aluminum, of the various alum salts and of abrasives. Bauxite is exceedingly variable in its composition and great care is necessary in the selection of the raw ore for the manufacture of refractories and the maintenance of their uniformity. Bauxite ore will analyze as follows:

	Per Cent
Fe_2O_3	3.0 to 6.00
Al_2O_3	55.0 to 60.00
SiO_2	4.0 to 7.00
TiO_2	2.0 to 2.75
H_2O (Water of Crystal)	30.00
Moisture	1.50

The ore must be thoroughly calcined at high temperatures to wholly remove the water of crystallization and so reduce the shrinkage; suitable bonding clays are then added and the brick are burned at the highest temperatures of the kilns.

Characteristics of Bauxite Brick

The original troubles in the use of bauxite were, in a great measure, due not only to deficiencies in the bonding material, but to insufficient calcination of the raw stock and the attempt to burn at too low temperatures. A high grade bauxite brick should run as high as, say, 56 per cent in alumina, a fairly representative analysis being given in the table below. It can, however, be manufactured with a still higher content of alumina where conditions warrant. The term "bauxite" as applied to brick is, however, used so loosely that little meaning is conveyed unless at least the approximate analysis is known. Many of these brick will show on a determination only from 43 to 51 per cent in alumina. If properly made, the brick is physically strong and tough, but with somewhat of a tendency to spall if

suddenly cooled or heated. Bauxite brick will analyze as follows:

	Per Cent
SiO_2	38.38
Al_2O_3	56.77
Fe_2O_3	2.95
CaO	.00
MgO	1.09
Alkalies	.88

Chrome brick are made from imported chrome ore and contain about 40 per cent chrominum oxide. Magnesia brick are made from imported grain magnesite and will show approximately 85 per cent magnesium oxide.

While I have stated before that we are all familiar with fire clay brick as a refractory material, I fear that but few of us realize what determines the refractoriness of a fire clay brick. Refractoriness means having the quality of being refractory, which in turn means resisting ordinary treatment, difficult of fusion, or, in other words, will not yield readily to heat. I am positive that a good many of the treatments to which you put fire clay brick are away beyond the ordinary. How many of you pay as much attention to the selection of your fire brick requirements as you do to the selection of your molding sands, facing materials and other requirements? You will try out a fire brick in an installation and if it gives the service you understand is about the average to be expected, it is the brick you will adopt. What leads you to make this selection is a record of the service it has given elsewhere; and this is about all you take into consideration. While your conclusion may appear to be logical, it does not always hold out, for I have often noted instances where furnaces were built in exact duplicate of those at some other place, and while built of the same brand, the brick would not give one-half the service they gave at the other plant. This variation in the service is certainly not in the brick.

Every superintendent of a foundry insists on knowing the analysis of the coal he is using, while but few investigate the analysis and physical characteristics of their fire brick and fire clay requirements. All fire clay brick are essentially silicates of alumina and expressed in the lowest terms are composed of the two varieties of clay, namely, the hard, flint or

block clay, as it is often termed, which forms the real body of the heat-resisting material, and the soft or plastic clay, acting as a bond to give physical strength to the brick. As conditions may warrant, a larger or smaller portion of the hard clay may be calcined previous to its manufacture into brick. Upon the character of these clays, the fineness to which they are ground and the degree of burn given them, depends the character of the brick. In general, a fine ground, hard burned brick giving superior results in the side walls and a more porous, open, and if we may term it, "elastic" brick doing better in arch work. There is here given a fairly representative analysis of a high grade Pennsylvania fire clay brick, cited as being merely typical.

	Per Cent
SiO_2	52.93
Al_2O_3	42.69
Fe_2O_3	1.98
CaO	.33
MgO	.38
Alkalies	1.55

It has been demonstrated, other things being equal, as the percentage of silica increases in a fire brick, the refractoriness decreases, the excess of silica being in a free state and uniting with such impurities as may be present, lowering the fusion point of the brick.

The theoretically perfect fire clay, a true silicate of alumina, will show in accordance with the oxygen ratio the following:

	Per Cent
Alumina	53.27
Silica	46.73

Such a pure silicate of alumina does not, of course, occur in nature, but as a general rule, the nearer the silica and alumina are to these proportions, the more refractory is the material.

Analyses of fire brick taken from various foundries where trouble has been encountered have shown from 59 to 73 per cent of silica, or an even higher percentage. Of the majority of clays used in foundries such analysis indicates that they are made from so-called top vein clays, lying above the coal

measures, and such as are more commonly used in the manufacture of sewer pipe, building brick or fire proof material.

Analysis not the Only Criterion

Nevertheless analysis alone does not tell the story as to how any given clay or brick will work out in your furnaces, in the side walls, for instance, where it encounters high temperatures, the scorifying action of the slag and cinder and the wear and tear of the slice bar or poker. Nor will it tell the results in the arch, often subjected to the most intense heats, with forced or induced draft, with mechanically fired furnaces and with fuels of various kinds.

However, certain analyses may show on inspection that the fire brick is wholly unsuited to the work in hand, yet other brick of good analyses may fail due to the physical structure of the clays or of the brick as influenced by the process of manufacture.

The physical structure of the brick should also be considered in making decision as to its selection. Where bituminous coal is used as the fuel, it has been found that a hard dense brick of higher refractoriness gives the best results in the side-walls, especially along the clinker line. The importance of using a brick of the proper physical and mechanical composition in side-walls has brought about the introduction of bauxite for this portion of the furnace construction. While they have not as yet probably been given an adequate test, their adoption bids fair to later become a factor in the selection of the material used in lining at least portions of the several different kinds of furnaces in your equipment. It will be dwelt upon more fully later.

Ordinarily a brick used in the arches should be of not too hard a burn and of a comparatively coarse grind, as a brick of this kind will better withstand the sudden changes of temperature encountered.

There are, of course, variations to this rule, as with the use of anthracite coal with blast or forced draft, where the physical structure of the brick should be dense and hard to

better withstand the cutting action of the fast moving gases of combustion.

Care should be exercised in selecting a fire clay for laying up the brick-work of a refractoriness corresponding with the brick. When a manufacturer of a high grade brick begins to insist that it should be laid up with a clay corresponding in refractoriness his motives are not invariably looked upon as altruistic, but it is a common error to use so low a grade of clay that its plasticity must be reduced by the mixture of sand to give a sufficient sharpness to work the material. In such a case the joints may often melt and run out while the brick themselves would be unaffected. Any addition of lime, mortar or cement should be avoided, not so much because of the injury done by a very small percentage of this material, as because of the fact that any given percentage is in practical working very often doubled or tripled, due to carelessness in proportioning the mixture.

Refractories for Air Furnaces

Air furnaces are particularly severe on fire brick. This is due not so much to the high heats attained, as to the intermittent operation of this type of furnace. The highest grade of fire brick obtained is none too good and care should be exercised in the selection of brick of the proper burn to withstand the variable conditions occurring during the operation of the furnaces.

Hard-burned and fine ground brick should be used in the sidewalls of these furnaces to better withstand the impinging effect of the flames against the walls, deflected, as they are, from the stock which, when originally charged, is very bulky and takes up considerable of the space of the melting zone. Medium burned and coarse ground brick should be used in the roofs to overcome spalling and to withstand the variable temperatures naturally occurring.

Considerable of the difficulties with the clinker of the fuel bed adhering to the sidewalls of the combustion chamber have been overcome by the use of a steam-pressed brick along this clinker line. The use of bauxite brick and steam pressed

brick has also overcome to a very considerable extent the scorifying action of the slag of the bath upon the sidewalls of the melting zone.

The sidewalls of this type of furnace have to be repaired very often due to the action of the slag of the bath cutting out the brickwork wherever it touches and thus undermining the upper portion of the walls. Chrome and magnesia brick would resist the action of this slag because of the fact that the one is slightly basic and the other neutral and while satisfactory on this score, they have been found unsuited for the reason that they will spall due to variable temperatures occurring during the intermittent operation of these furnaces.

Annealing Furnaces

As the temperatures employed in annealing furnaces will vary from only 1000 to 1500 degrees or possibly a little higher, a second quality brick is used almost entirely throughout excepting in furnaces of great width and where the flame of combustion has to carry a considerable distance. Here it has become necessary to use a first quality brick in the fire boxes of those that are coal fired on account of the higher temperatures necessary to carry the heat across the furnace.

The best practice is to install the bottom of these furnaces with tile 12 inches in width and 5 inches thick, varying in length from 12 to 18 inches. These tile are made as tough and dense as it is practical to make them, so that they will stand the wear and abrasion encountered in the charging of the furnace. As each of these blocks covers a larger area than a standard size 9-inch brick, they afford a more even surface and considerably reduce the number of joints in the brick work of the bottoms.

Brass Furnaces and Steel Converters

In brass melting furnaces of the pit type wherever a crucible is used and where coke or oil is ordinarily the fuel a highly refractory brick of medium coarse grind and of a good strong burn give the best results. A brick with these char-

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acteristics will better resist the action of the fused coke and the deposits from the oil.

In the tilting melting type of furnace the most refractory fire clay brick obtainable is required to secure good results. The brick should be of dense structure and of hard burn to resist the action of the oil and air which are admitted usually under very heavy pressure. The slags created are very scouring in their action and consequently do not permit of the use of an open or coarse grained brick. Specially shaped brick are usually required to line this type of furnace, to overcome the number of joints occurring when lined with standard brick. A good many of the above furnaces are lined with ganister, which makes a very satisfactory lining material as it can be repaired very handily.

In steel converters the lining most generally used is silica brick while there are a number lined with ganister which is a mixture of practically pure silica grits and a refractory clay, which is rammed around wooden forms. Many of these converters are first lined with silica brick to the surface of which is then added a coating of about three inches of ganister. I know of some converter linings thus installed that have given over eighteen months' service.

Considerable of the difficulty with the linings of the converters is due originally to their design, and owing to this standard brick cannot be used, consequently special shapes have to be made up. Any deviation from the original dimensions necessitates the chipping of the brick which creates additional expense and results in an unstable lining.

In core ovens the temperatures attained require the use of only red brick excepting in the combustion chamber where a second quality fire brick will suffice.

In crucible steel melting furnaces which are usually of the regenerative type, the use of silicia brick is rapidly replacing clay brick in the lining of the melting zone. Where formerly there was obtained about four to six months' service with the clay brick lined furnaces we have records of furnaces lined with silica brick giving a life of from 36 to 45 months; the average life of these furnaces today is from 14 to 18 months.

In the middle west there is used what is termed the Milwaukee or German type of crucible furnace. These are oil fired and natural draft furnaces. To resist the sudden changes of temperatures occurring in this type of furnace due to the removal of the bung or covers and ordinary shut downs, it has been found necessary to adopt a special fire clay brick, which while very refractory to withstand the high temperature, is of a very coarse grind and of a light burn.

Brick for the Cupola

Brick to be used in cupolas should be dense, hard, tough and very refractory. Blocks for lining around the bottom of the cupola and for a distance of four feet or so above the tuyeres should be made of flint clay high in alumina, with sufficient bond clay to make the brick strong and tough. The manipulation of the clay and the mix, grind and burn have to be carefully considered to secure the maximum heat resisting capacity, together with ability to stand the cutting action of the blast and the wash of metal and slag.

From a distance of about two feet above the tuyeres to the charging doors the blocks should be made to withstand abrasion, as well as heat and they should be exceedingly dense, hard and strong.

The economy of using high grade material is becoming more and more recognized. It is not so much the few dollars per thousand extra that may be paid for brick of the highest grade as compared with the price of material not so good, but the fact that stoppage for repairs, and consequent loss of output are reduced to a minimum.

Chrome and magnesia brick could be used to advantage in certain portions of the cupola linings if it were not for the variable slags occurring. Silica brick also have been used in some instances with success, but where an effort is made to keep the slag as neutral as possible the clay brick answer the purpose more satisfactorily than any other brick.

In the electric furnaces silica brick are used entirely, excepting where basic steel is produced, the latter requiring

that the bottom and side walls be constructed with magnesia brick to withstand the action of the basic materials charged into the furnace. It is surprising how well these brick have withstood the severe treatment given them in this type of furnace. While we all appreciate that silica and magnesia brick will spall severely when subjected to sudden changes of temperatures and fully realizing the intermittent operation of these furnaces, still we would not consider any other refractory material than silica or magnesia brick to withstand the high temperatures occurring therein.

The life of the lining of an electric furnace is at the best a very short one and considerable of the difficulty with the short life of these linings is due to a very considerable extent to the unnecessarily high temperatures often attained. While they have all sorts of devices for registering the voltage and amperes required during the melting of a charge, there is very little attention given to the temperatures attained. In fact, there is no instrument that can be depended upon to record accurately the high temperatures that no doubt are often attained during the operation of the furnaces. I have heard operators of these furnaces state that they judge the working temperature to be slightly over 1900 degrees Cent. This would mean a temperature of about 120 degrees Fahr. beyond the fusion point of the brick. I have seen the original lining of an electric furnace run for 48 consecutive days and the four or five subsequent linings would last from five to ten days.

Hard Work in Malleable Furnaces

Regarding malleable furnaces this practice is about the most severe of any on fire brick. The life of these furnaces is referred to in the number of heats and not days or weeks, and is governed by the service obtained from the brick in the sidewalls, as the roof sections or bungs are often renewed during the operation of the furnace.

The repairs to the sidewalls are occasioned by the action of the slag in cutting out their support and thus undermining them. To resist this action magnesia and chrome brick have often been tried, but without success, owing to the manner of

charging this type of furnace, that is, the removal of the roof thus permitting the brick work to cool off rapidly and causing the magnesia and chrome brick to crack and spall.

Fine ground and hard burned brick should be used in that portion of the sidewalls as high up as the slag line reaches. Hard burned and highly refractory brick should be used in the balance of the sidewalls to resist the impinging effect of the gases of combustion and coarse ground and light burned brick should be used in the bungs to better withstand the variable temperatures naturally occurring in this practice where coal is the fuel most generally used.

In the steel foundry most of the steel is made in acid open-hearth furnaces and as the name implies acid linings are required. These are created by the use of silica brick entirely throughout the melting zone and upper portion of the furnaces.

These furnaces are all of the regenerative type whether natural gas, producer gas, oil or pulverized coal is used as the fuel and thus regenerative chambers filled with brick are required. The brick most generally used as checkers are first quality clay brick, fine ground and of medium burn as they will more readily take up and give off the heat of the gases.

This checker work is often topped off with from four to ten courses of silica brick while there is a constantly increasing number of operators using silica brick entirely. Checkers installed with silica brick become choked less readily than do those installed with clay brick as the carbon coating does not seem to penetrate and adhere to the brick as is the case with the clay brick.

The regenerative chambers, walls and crowns are generally built up of first quality fire brick. However, in a number of instances silica brick are used in the crowns and upper portions of the side and division walls as they will better withstand the weight, thus overcoming considerable of the settling of the walls and thereby preventing leakages. Silica brick for these furnaces should be selected upon their analysis, burn and workmanship.

Where the steel is made in the basic furnace, magnesia and chrome brick are used in addition to the silica brick

previously mentioned. The bottom and the sidewalls are installed with magnesia brick to a height of about 12 inches above the fore plate level. These are topped off with a course of chrome brick before the sidewalls of silica brick are started. After the furnaces are thoroughly heated additional bottom is then put in the furnace by the use of ground magnesite.

Selection of Electric Motors and Controllers for the Foundry

By S. H. Libby, New York.

The selection of electric motors and controllers for foundry use presupposes the selection of the proper kind of electric energy to suit conditions, and while alternating current is in many cases as well adapted for foundry work as direct current there are places in which the direct current motor has a distinct advantage over the alternating current.

As a study of the different uses to which the motor is to be put will best show the requirements, we will investigate the requirements for crane motors, and assume first that direct current is available.

The voltage at our conductors is, of course, immaterial as far as operation of our motors is concerned, but should preferably be 230 volts, as at this voltage insulation is not as hard to maintain or the danger as great as at 500 volts, and the cost of copper in the conductors is appreciably less than if 115 volts were used.

In all probability there is nothing as indefinite about a crane or hoist as the rating given to the motors by the various crane builders, one size frame, for instance, being rated at any point between 5 and 15 horsepower.

As ordinary crane service is far more intermittent than the duty in the majority of cases where electric motors are used, the motor may, of course, be rated higher than if used for other duties. For ordinary crane work it has been found that a rating based on a half-hour run with a rise in temperature not to exceed 55 degrees Cent. is conservative. If, however, the duty becomes more continuous the rating must be changed accordingly.

For ordinary uses the speed of the apparatus has little to do with the selection of the motor, but for hoist duty, particularly where patterns are to be drawn or copes lifted,

the results to be obtained depend to a very great extent on the proper selection of the motor and control. As it is possible to handle light loads at much higher speeds than heavy loads, the empty crane hook should be capable of being raised or lowered at a much greater speed than the full load speed, thus effecting a saving of time and increasing the efficiency of the cranes. Years of experience appears to indicate that a no load speed of double full load speed is very satisfactory, and easy to obtain with a properly designed motor.

In considering the hoisting and conveying of material, we find that the duty is analogous to railway work in that the motor must start and accelerate under full load, and for that reason the same type of motor is desirable, that is, a series motor. For our hoisting and conveying the series motor is not only well adapted on account of its high starting torque and simplicity of control, but also on account of its tendency to speed up under no load, resulting in an increased speed of the empty hook, thereby reducing the time required to complete a given cycle of operations.

If the motor is so designed as to give a no load speed of double that of full load, the high speed will not be so great as to result in damage to its rotating parts, and if it is correctly proportioned magnetically and otherwise, the highest peripheral speed will not be dangerous.

Fig. 1 shows the characteristics of a typical crane motor, the speed of the armature being plotted against the load on the hook. It will be noted that while the full load speed of this machine is 1,000 revolutions per minute the three-fourths load speed is 1,100 revolutions per minute, the curve showing a fairly straight line and nearly equal increase in speed from full load to one-half load, but at a point between one-half and one-fourth load the direction begins to change until that portion of the curve lying between one-fourth load and no load has become more nearly vertical and the change in speed is much more rapid than the change in load. This curve is taken from the characteristic curves of a line of crane motors which have proved very successful in service, from the operations of which our deductions have been made.

The crane motor should also combine another of the characteristics of the railway motor in that it must be weather-proof, thus insuring the protection of its interior from the moisture and fine dust so prevalent in foundries. For this reason the doors should fit motor brackets by means of machined joints. Crane motors should also, like the railway motor, allow of the fixing of the brushes at one point and the reversal of the motor without undue sparking.

An analysis of the requirements in foundries indicates that two general types of control are necessary, one for handling flasks in the flask yard, or for handling coal, coke, pig and sand; while the other is for use in the molding shop for drawing patterns, lifting copes, and pouring off. If these two requirements may be satisfied with one controller combining the two types, the problem is simplified. For the first type a rheostatic controller will be sufficient. Such a controller should allow of lifting half-load on the first notch, at one-quarter to one-third full load full speed. This will mean an arrangement of resistance which will allow of 75 per cent of full load current flowing on first notch when motor is at a standstill. Such an arrangement will give sufficient allowance for overcoming the starting friction of the entire machine and also for acceleration.

Fig. 2 is plotted to show the speed of one-half load on the various notches of a seven point controller, from which it will be noted that the approximate full load speed is reached at the fourth notch. This curve also shows the rush of current as the controller is turned to each successive point, the lower point of curve denoting the running current for half-load, the difference between that point and the upper point denoting the current utilized in acceleration. Taking full load which requires approximately 35 amperes, we find that it could not be started on the first notch, as the maximum current on that step is only 26 amperes. Turning the controller to the second point gives a current of 39 amperes and as the running current is 35 amperes the difference of four amperes is not enough to overcome the static friction and accelerate the load, and the controller must, therefore, be turned to the third point.

A reference to Fig 3 shows that the first rush of current on this point is 60 amperes, leaving 25 amperes to start and accelerate. This curve also shows the current on the different points which is available for acceleration. From these curves we find that a variation may be obtained from half-load at about quarter speed, to full load full speed, which variation is entirely acceptable for crane work falling within our first

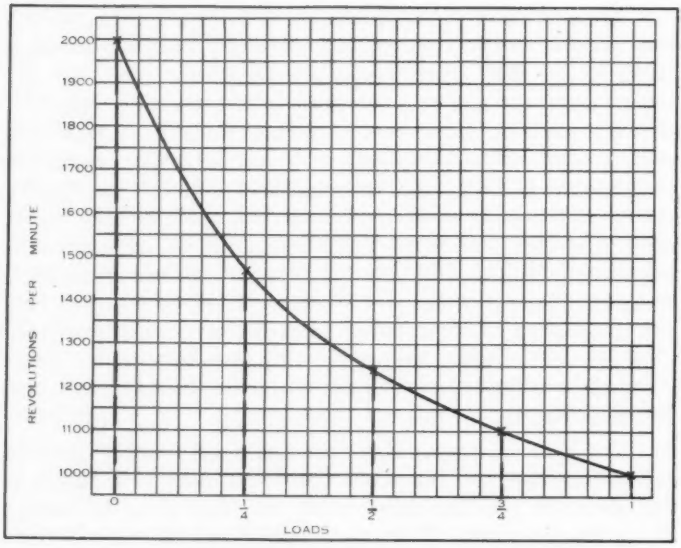

FIG. 1—CHARACTERISTICS OF TYPICAL CRANE MOTOR

requirements, but it would be entirely inadequate in fulfilling our second requirements.

Suppose, for instance, it is desired to draw a pattern which may reasonably be expected to weigh at most not more than one-fourth of full load, the results if the attempt is made with our rheostatic controller are shown in Fig. 4, where our slowest speed is more than 75 per cent of full load full speed. It will probably be said that the first point of resistance may be so changed as to allow of handling light loads at slow

speeds. This is true, but in changing to accommodate the light loads we have spoiled its use for half or similar loads.

Assuming a required starting current of 33 per cent over the running current, and one-fourth load to lift, our current at start must be 18 amperes and drop to 13 amperes at the end of the accelerating period, and with resistance so arranged as to produce those results half-load could not, of course, be started on that point, and it would, therefore, be necessary to use the second point for starting that load, thus adding another point to our controller. One-quarter load, however, is

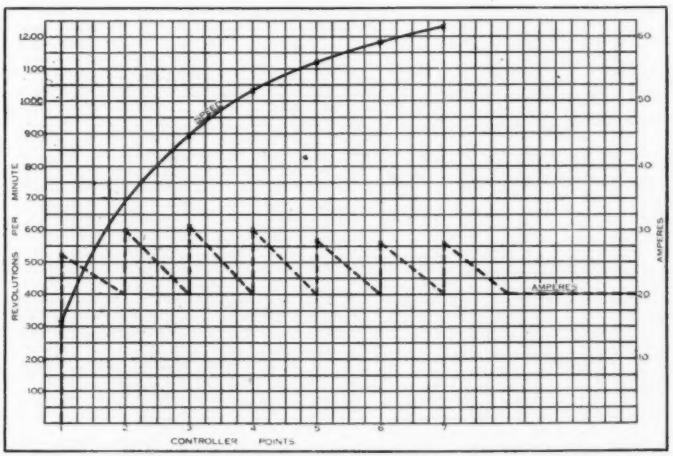

FIG. 2—SPEED AT ONE-HALF LOAD ON SEVEN POINT CONTROLLER

a rather heavy allowance for the pattern in most cases so that we should be able to handle a still smaller load on the first point, say one-eighth load.

One-eighth load would require approximately seven amperes running current and 9.5 amperes to start, including acceleration. This would mean that one-fourth load must start on the second point and one-half load on the third point, thus adding two points to the controller and making it necessary to "feel" the controller along until the point at which the load will start is reached.

This not only results in a cumbersome controller, but in a loss of time if the molder is also the hoist operator, as in the case of light work with floor control, where the hoist is intended as additional equipment in the molder's hands to expedite his work. Again, the great variation in speed on the same controller point, with a change in load, may result in bad work, not only on account of too high speed for drawing patterns and lifting copes, but also on account of the sudden increase in speed as a sticky flask becomes free. Fig. 5 shows what may be expected of rheostatic control when such a change

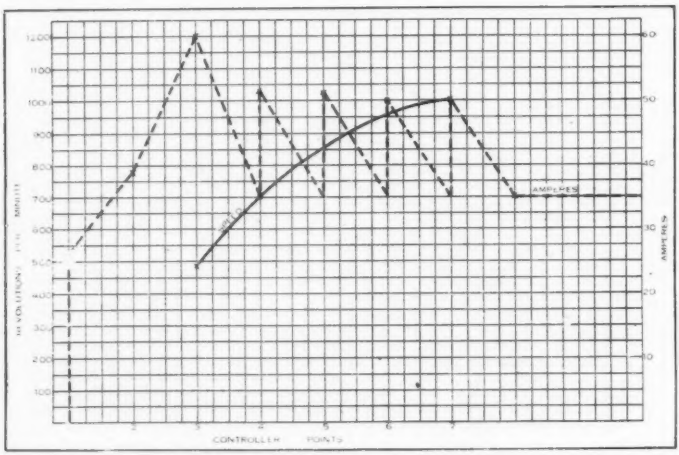

FIG. 3—CURRENT AVAILABLE FOR ACCELERATION

in load occurs. This curve shows the speed of smaller loads when run on a controller point designed to give one-quarter speed at one-quarter load.

It is very evident then that the rheostatic controller is not the ideal controller for use in the molding shops, particularly because it does not give a sufficiently constant speed with a wide range of load on the first notch, and we must, therefore, find something which will show different characteristics. What is desirable then is a controller which will approximate as nearly as possible on the first notch the constant speed char-

acteristics of the shunt motor, and yet retain the series motor characteristics on the other points. With a properly designed motor this may be accomplished by arranging a resistance in shunt with the armature in addition to a series resistance.

Fig. 6 shows the characteristics of such a motor for so-called foundry control and also for rheostatic control.

It will be noted how much flatter is the curve for "foundry" than for the rheostatic control, showing comparatively little change in speed from one-quarter load to no load. This

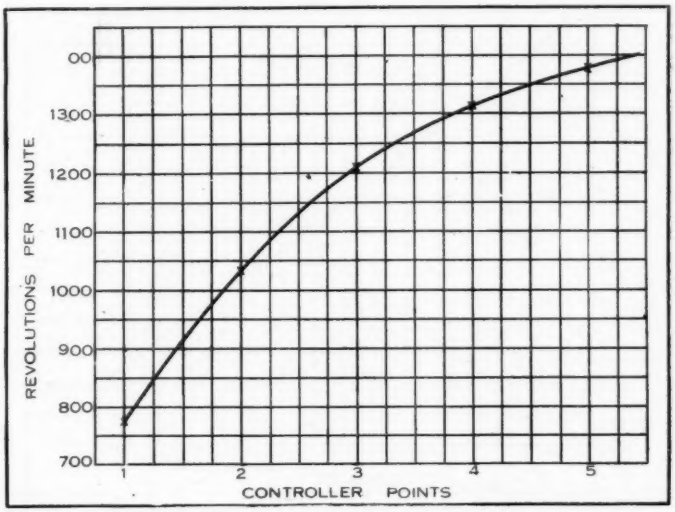

FIG. 4—SPEEDS WITH ONE QUARTER LOAD

comparatively small change in speed is, of course, desirable for it means that in drawing a pattern which weighs one-eighth of full load this speed would only be 60 per cent higher than if the weight was one-quarter of full load.

Or, to put it still plainer, if the speed at one-quarter load were two feet per minute the speed with one-half of that load or one-eighth full load would be 3.2 feet per minute, not a prohibitive speed and one easily controlled, as the operator has only to turn the controller to the first point and he gets the

proper speed for all loads within a wide range without juggling the controller.

In this particular class of work the direct current motor shows its superiority over the alternating current as a glance at Fig. 7 will indicate. On this curve it will be noted that we are starting at a point at which one-quarter load may be accelerated and that at that load the speed reaches 300 revolutions per minute. If, however, the load is one-eighth of full

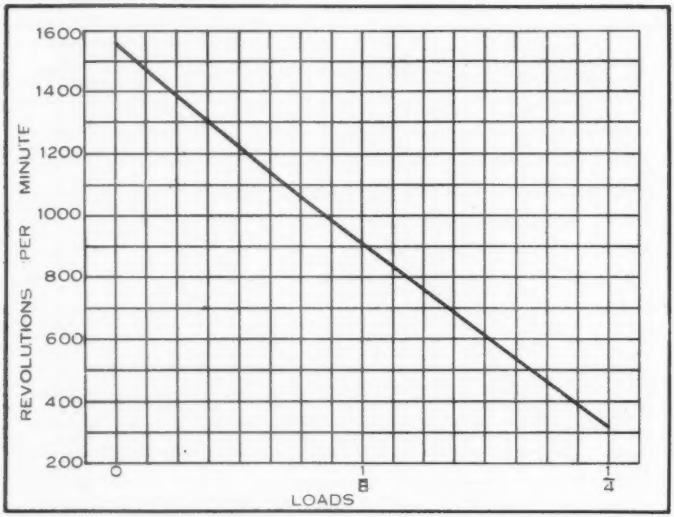

FIG. 5—SPEED VARIATIONS WITH RHEOSTATIC CONTROL

load the speed will reach about 750 revolutions per minute, or more than twice the one-quarter load speed. A comparison of the two curves as to angle with the base line discloses this graphically, both curves being drawn to the same scale.

For other than crane duty the general requirements appear to be similar to those obtaining in certain heavy tool operation, such as planers, punch presses, etc., and motors which would best meet such requirements should prove satisfactory for foundry work.

One characteristic which such motors should have in common with the crane motors is that of being totally enclosed, as in spite of any method of boxing or housing which is generally in vogue in foundries, the fine dust permeates to the motor and invariably results in more or less trouble. For general use on tumbling barrels, sand carriers, mixers, etc.,

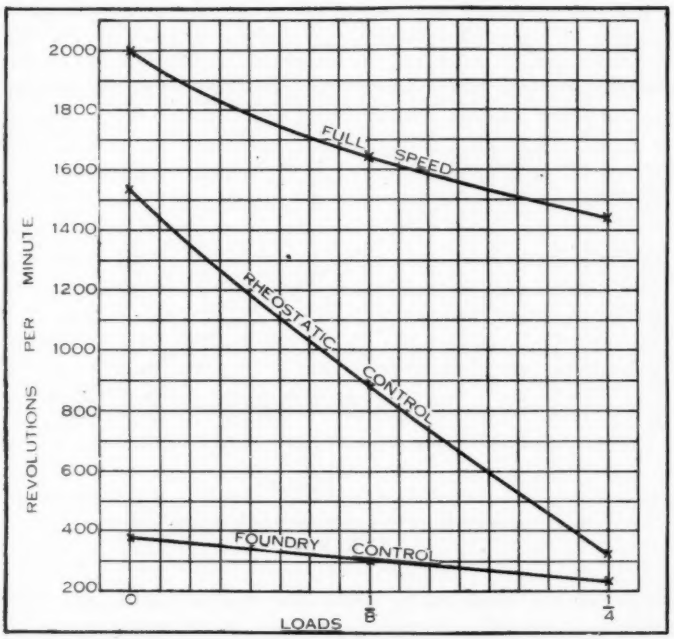

FIG. 6—FOUNDRY CONTROL AND RHEOSTATIC CONTROL CONTRASTED

a compound wound motor with a series field of 10 to 15 per cent should be used if direct current is used, as the characteristics of such a motor would enable it to keep the apparatus in motion under heavy overloads without any bad results at the commutator. Such a motor would also start a heavy load, to which it might be direct connected, such as tumbling barrels

or sand conveyor, with the same absence of commutator trouble.

If alternating current is being used a slip ring motor should be specified, as such a motor will be capable of gradually starting such machines as may be loaded although not running.

In selecting motors for the general uses above described, a mistake as to the size should be, of course, avoided, and it is quite as much of a mistake to select a motor which is too

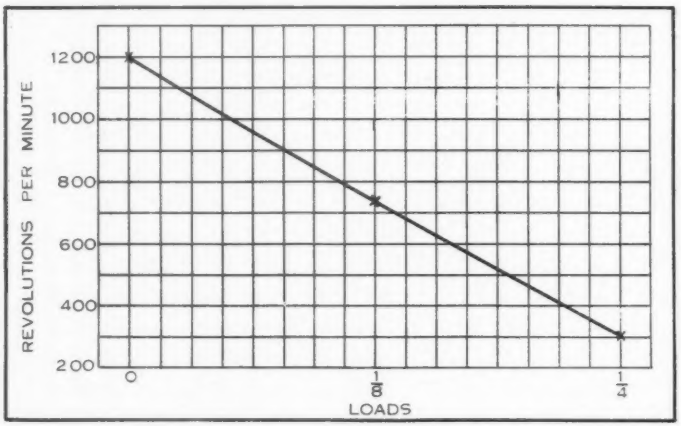

FIG. 7—ALTERNATING CURRENT MOTORS WITH RHEOSTATIC CONTROL

large for the work as to select one that is too small. The small motor would, of course, burn out, necessitating repair or replacement, while the large motor would not only be expensive as to first cost, but inefficient while running at small load.

In selecting controlling devices much will depend upon a careful study of the actual conditions, as a control which would be satisfactory in one case might prove entirely inadequate in another. For instance, if a machine is to be started and stopped frequently as would be the case of a lathe or planer, an automatic or push button control, of which little is generally known, would prove to be a good investment, in spite

of the seeming high first cost. Such a control not only eliminates the results of carelessness or ignorance on the part of the operator, but also has the added advantage of safety in the event of failure of current, as under such conditions everything goes to "off" position and the full cycle of operations must be performed again before the motor can be started.

For ordinary uses, however, where a machine is started but a few times each day, the simpler form of controller is satisfactory. As an auxiliary equipment for motors of 25 horsepower and above, an ammeter has been found to be of considerable value in detecting increased load due to lack of lubrication, to faulty adjustment of the driven machine, or to a tendency of operators to overload the machines. Such a device would also show if the motor was too large or too small, and so allow of a change in the equipment to give better results.

From the foregoing it may be seen that each problem must be carefully studied in order that a proper decision may be reached as to: (a) The selection of alternating or direct current; (b) the type of motor; (c) the type of control, and (d) the size of motor. Without such study the results are sure to be anything but satisfactory.

The Economics of Electric Motor Drive

By H. F. Stratton, Cleveland, O.

Profit is the excuse for existence of industry. Profit is what you gain, but to have meaning or significance, profit must be measured in terms of some quantity instrumental in its creation. Considered as an insular quantity, profit is as indeterminate as a fraction with an unknown denominator. Profit may be variously compared; it may be known as a percentage of cost or sales, forgetting investment; more properly, it may be called the return upon investment.

Viewed fiscally, when the policy and management of an enterprise result in that balance which makes a maximum ratio of profit to investment, then, for that industry, capital is most efficiently employed. Viewed practically, the topic is infinitely more complex; most companies are not fortunate enough to know of the existence of enough articles, yielding maximum profit upon investment, to utilize capital already available; in fact, did any individual or any company possess such insight and knowledge, there would be practically no limit to the amount of capital which he could command.

The result is that we manufacture many articles of widely varying desirability from the view point of the relation of profit to investment. The profits on some articles are meager, compared with the investment in equipment necessary to convert raw materials into finished products; others are more satisfactory. In some cases, profit is made temporarily and artificially large by the failure to insure a reasonable presumption of the continuance of profit.

Is it possible, out of this maze of facts and conjecture, to seize any basic principles and codify them? If it is possible to find any laws governing the economics of machinery, any fundamental principles to guide one in determining what to build and what not to build, then in so doing, we touch upon questions of great economic and fiscal importance.

I must reluctantly abandon the pleasing generalities of this suggested train of thought, and confine the discussion to matters pertinent to the topic. The case I have attempted to establish is that the relation of profits to invesment is very important because, as a matter of fact, it is the basic relation, which, when favorable, attracts capital, and which, when unfavorable, repels capital. This, indeed, seems such an obvious truism that it ought not need to be stated.

Costs Are Increasing

I ask your indulgence if I attempt to discover, statistically and analytically, what has been the recent trend of progress in your industry. Unfortunately, the U. S. census reports do not deal with foundries alone, but group foundries and machine shops under one head, and the accuracy of any attempted deductions, to a certain extent, will be marred by this blending of statistics.

Table I is copied from an article by A. E. Rickards in *The Electric Journal,* and was deduced from the U. S. census reports.

TABLE I.
THE FOUNDRY AND MACHINE SHOP INDUSTRY—ALL ESTABLISHMENTS.

Item No.	Item	1903	1913	Percent Increase or Decrease
1	Number of establishments	11 180	13 414	20. inc.
2	Capital	$806 902 401	$1 543 558 607	91.5 inc.
3	Primary horse-power	463 231	889 212	96. inc.
4	Value of products	$833 627 841	$1 281 053 730	53.8 inc.
	Cost Items			
5	Materials	$371 385 000	$ 552 431 000	48.7 inc.
6	Wages	224 553 000	328 369 000	46. inc.
7	Salaries	41 991 000	100 173 000	138. inc.
8	Miscellaneous expenses	57 295 000	129 336 000	125. inc.
9	Total cost	695 224 000	1 110 309 000	59. inc.
10	Total profit	137 401 000	170 743 000	24.5 inc.
11	Percent profit on capital	17	11	54.5 dec.
12	Number of wage earners	436 293	542 587	24.3 inc.
13	Number of salaried employees	35 743	77 794	117. inc.
14	Average salary per salaried employee	$1175	$1287	9.65 inc.
15	Wage per wage earner	515	605	17.4 inc.

Note that investment increased 91.5 per cent, output 53.8 per cent, and profit only 24.5 per cent. This is a diminishing set of figures.

Table II expresses profit and the elements of cost as a percentage of sales, for the years 1903 and 1913. Fig. 1 enables one to visualize the condition established by Table II.

TABLE II.
COST AND PROFIT AS PERCENTAGE OF SALES.

Item	1903	1913	Percent Increase or Decrease
Materials	44.6%	43.1%	1.5 dec.
Wages	27.0 "	25.7 "	1.3 dec.
Salaries	5.0 "	7.8 "	2.8 inc.
Miscellaneous expenses	6.9 "	10.1 "	3.2 inc.
Profits	16.5 "	13.3 "	3.2 dec.
Totals	100.0%	100.0%	

Materials and wages decreased: salaries increased and the increase equals the sum of the decreases of material and wages. Miscellaneous expenses increased and profits decreased by the amount of the increase of miscellaneous expenses. Possible reasons for the increase in salaries and miscellaneous expenses are: *First,* increased selling expense due to more competition; doubtless much of this is non-productive and useless; unfortunately it cannot be stopped except by agreement which the Government prohibits. Hence, so far as this factor is concerned, we have the spectacle of the Government insisting

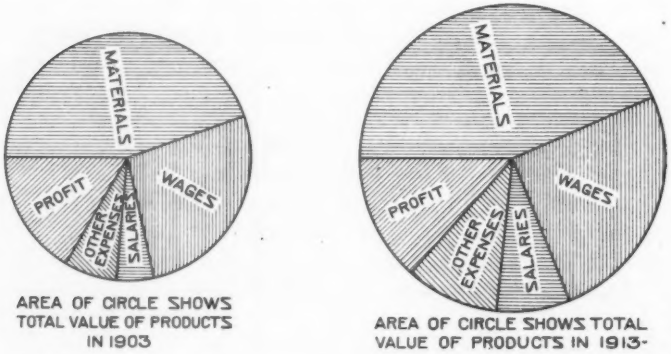

FIG. I

that the cost of production shall be increased by insisting that selling competition shall persist. *Second,* increase in the number of foremen; increased supervision of men together with the use of more efficient machinery has probably helped make the favorable showing in regard to wages. *Third,* increased

depreciation on increased equipment. *Fourth,* the establishment and maintenance of expensive cost systems; these have probably generally been good; the obviously bad cases are those where ten dollars are spent to save one dollar.

Having made this superficial study of the statistics of your industry, we are now face to face with the greatest problem of modern manufacturing. This is the triangular conflict between labor, investment, and production. It is a battle maintained by an economic movement of terrific power, by the mental acumen of those who design the means for manufacturing and those who direct the operations of manufacturing, and finally by an expenditure, on the part of capital, of billions of dollars.

On one side, we see labor demanding and getting more wages, shorter hours, greater expenditures in the interest of safety and welfare. Unfortunately—it seems to me—we also see labor in certain industries protesting against the increased efficiency of labor; insisting that a man shall do, not what he can, but only what the average can; communistic mediocrity preferred to individual opportunity.

On the other side, we see the combined might of capital and a small army of specialized thinkers, struggling to increase production that profit may not be annihilated. Not millions, but billions are spent for improved equipment that the workman may produce more, or that a $3 man may displace a $4 man. Machinery is designed so that numerous operations are performed simultaneously, automatically and rapidly. Manufacturing operations are planned and standardized, speeds and feeds are specified, in order that output may depend, not upon the initiative of the workman, but upon the capacity of the machine. Material is routed to travel the least possible distance in its conversion from raw to finished products. The principle of the division of labor—detected and eulogized by Adam Smith over a hundred years ago—is carried to a degree of completeness, heretofore apparently impossible. Capital and brains are successfully consummating a condition where manufacturing operations are largely independent of the initiative and skill of the workman; with some truth, I might say, even of the intelligence of the workman. Let me quote three para-

graphs from a recent article by Horace A. Arnold in the *Engineering Magazine,* describing the methods of The Ford Automobile Co.

> "The foundry superintendent asserts that if an immigrant, who has never even seen the inside of a foundry, cannot be made a first class moulder of one piece only in three days, he can never be of any use on the floor; and two days is held to be ample time to make a first-class core maker of a man who has never before seen a core-moulding bench in his life.
>
> "As to machinists, old-time, all-round men, perish the thought! The Ford company has no use for experience, in the working ranks, anyway. It desires and prefers machine-tool operators who have nothing to unlearn, who have no theories of correct surface speeds for metal finishing, and will simply do what they are told to do, over and over again, from bell-time to bell-time. The Ford help need not even be able-bodied.
>
> "I cannot forbear here repeating my statement that the successful results of the Ford company's unprecedented methods of utilizing unskilled labor in skilled repetition-production are of the highest interest, and should be fully detailed for careful study by all employers of repetition workers."

Right or wrong, labor is increasing production costs if equipment remains unchanged. Right or wrong, the manufacturer is changing equipment to increase the capacity of the individual workman and to replace skilled by unskilled labor.

Does it Pay?

Through the courtesy of John Frey, editor of the *International Moulders' Journal,* and A. E. McClintock, commissioner, the National Founders' Association, I received figures indicating the following condition: from 1903 to 1913, the average wages of the workman in a foundry increased not

TABLE III.

Item	Assumed	Actual
Investment	$1 241 015 893	$1 543 558 607
Wages	448 971 268	328 369 000
Salaries and Miscellaneous Expenses	152 701 868	229 509 000

less than 30 per cent. Assume that from 1903 to 1913, investment, salaries and miscellaneous expenses were increased only in the same ratio as production; also assume that wages grew in the same ratio as production and in addition, were increased by the 30 per cent advance; we then have the following comparison between the actual and assumed conditions for 1913.

Certainly not more than the difference between actual investment and the assumed investment was for the specific purpose of decreasing labor costs, by the installation of improved equipment; this difference is $302,542,714, which at 6 per cent represents a yearly charge of $18,152,562. Not more than the difference between actual and assumed salaries and miscellaneous expenses, was devoted specifically to decreasing labor costs. In both cases, however, let it be said that the entire extra expense was incurred to hold down labor charges. On the same basis of reasoning, the saving in labor is the difference between the assumed and actual wages.

TABLE IV.
BALANCE

Saving in labor costs		Expenses to reduce labor costs	
Wages	$120 602 268	Interest on extra investment	$18 152 562
		Extra salaries and mis'c. exp.	76 807 132
Total	$120 602 268	Total	94 959 694
		Net saving	25 642 574
			$120 602 268

If it be conceded that the assumptions are substantially correct, the saving in labor costs is greater by nearly $26,000,000 than the extra expenses incurred to bring about this saving.

Be it admitted that the reasoning includes numerous errors; nevertheless, if the items could be more accurately divided and apportioned, I believe a larger saving would be indicated. For instance, it seems probable that any given laborer, performing the same work with the same equipment, would do less work per day in 1913 than in 1903 because he works less hours per day; yet the assumption has been made, that he would accomplish as much work. Again, I have definite knowledge that in several large typical industries, selling expense, expressed as a percentage of sales, has increased conspicuously during the last ten years; yet, the assumption has been made that selling expense increased only in the same ratio as sales, and the balance of salaries and miscellaneous expenses has been charged to the effort to decrease labor costs.

Therefore, it is indicated that, in the foundry and machine shops, it does pay to decrease labor costs by using labor saving machinery and methods.

The leading statistics of the foundries and machine shops coincide fairly closely, with the average figures relating to all classes of manufacturing. This statement may be verified by referring to the U. S. census reports.

Therefore, it is indicated, in general manufacturing, that it pays to decrease labor costs by using labor saving machinery and methods.

The Field for the Electric Motor

Although the electric motor has not been mentioned, the previous discussion is justified because the electric motor, probably more than any other machine, is universally and importantly identified with the struggle to combat increased wages with increased production. In certain factories—for instance, the steel mills—the wonderful machinery and methods of the day, would be almost chaotic without the responsiveness and controllability of the direct current electric motor.

From 1899 to 1909, electric power grew from 5 to 26 per cent expressed as a percentage of the total power used in manufacturing. In the last seven years, it is calculated that while the cost of living has advanced 37 per cent, the average cost of electricity has gone down 17 per cent. Samuel Insull states that due to economics brought about in the generation of electricity, it now requires only 40 per cent as much coal for the same output of electricity as it did ten years ago. Important and sufficient reasons have caused the spectacular growth and cheapening of electric power; this has not been due to any figment of the imagination or the persuasiveness and personality of salesmen. I think the situation may be summed up very simply by saying the electric motor was needed; hence its development and wide adoption.

I propose to lay before you in considerable detail, the various reasons which have made the electric motor an indispensable part of an important economic movement. More specifically, I shall endeavor to explain, in what ways, the

electric motor has aided in the struggle to increase production and decrease dependence upon skilled labor.

Consider first the basic question of increasing the capacity of any given machine, say a lathe. What is the real working unit? Obviously, it is not merely the lathe, because one workman will do more and better work than another workman. Obviously, it is not merely the workman, because the same man will do more work on a good machine than he will on a poor one.

The important facts are these: The real working unit is the machine plus the average workman; the value of this working unit is gaged solely by the quantity of produced work which is good enough and the efficiency of the operation is largely the degree of intelligent co-ordination between workman and machine.

It is not absurd to consider that the modern machine has functions that are almost human; when the stops, levers and gears are properly adjusted, the machine does the work, precisely and repetitiously; the workman does the directing. Very appropriately, the machine might be called the worker and the man the operator. Hence, the operator should be furnished the utmost convenience and responsiveness to aid him in directing the machine. The properly controlled electric motor furnishes this link of convenience between operator and machine.

In this respect, an electric motor merely supplying power furnishes the least of the possible arguments for its use. It is not electric power, but rather controlled electric power that makes this subject so full of possibility and promise. It is the ability to make the electric motor perform flexibly and automatically the various operations necessary in high speed production. It is the responsiveness and power of the controlled electric motor that enables a workman to do more work with less fatigue. It is the elimination of useless thought, worry and physical exertion that permits a workman to bend all his energy and ability to his real task and to produce more and better work; and it is the blending of these qualities that furnishes the vital argument for the use of the electric motor.

Too often we find the question of a few dollars of extra cost for power or machinery overshadowing the vital consideration of what effect the new equipment will have on production and labor costs.

The accompanying table was deduced from statistics published in the *Electrical Review and Western Electrician*, and relates to three different foundries concerning each of which

TABLE V.

Tons per day	PROBABLE PAY ROLL				Cost of electricity per ton
	No. of Men	Per year ($2.75 per day)	Tons per year	Labor cost per ton	
5 to 10	40	$34.000	2,800	$12.15	$0.44
10 to 12	65	55.250	6,030	9.15	0.20
60 to 70	300	255.000	19,700	12.95	0.21
Average				$11.42	$0.28

figures were tabulated for one year. Each of these foundries was pretty thoroughly equipped with the ordinary electric drive, and in each case the approximate number of men employed, and the approximate tons of metal cast per year, were known. The average of these three cases gives the cost of electric power as 2½ per cent of the cost of labor.

The important deduction to be made is that any addition to the cost of electric power—even to the extent of doubling it—is relatively insignificant if, through its added convenience, only a small proportionate increase in production or decrease in labor cost is thereby secured.

Reverting to the motor driven lathe as illustrative, recent developments in controllers have provided an equipment that starts, stops, or reverses the motor in the shortest safe time, merely by moving a small lever to different positions. The operator need give no heed to the manner in which these operations are performed. The controller does this for him, automatically and better than he could do it himself. With such an equipment the operator is free from much useless mental and physical exertion. His mind is concentrated on his real task, with the obvious result that he produces not only more work but better work. The R. K. LeBlond Machine

Tool Co., a large manufacturer of lathes, before deciding to recommend and furnish such equipment as standard, made exhaustive trials of this apparatus in its own shops. The increase in capacity of the lathe, due to this modernized equipment, proved to be 25 per cent conservatively.

Cut the Time Between Cuts

As a division of this topic, examine the process of stopping a machine automatically by dynamic braking — which merely means the temporary conversion of the motor into a generator—instead of allowing it to come to rest merely through the effect of its friction. On a certain motor driven boring mill, 24 seconds elapsed before the machine came to rest by drifting. With dynamic braking, the same machine was brought to rest in 2½ seconds. Wages, salaries, taxes and all overhead burdens, did not pause each time these 21½ seconds were wasted. E. P. Bullard, in a recent address, said: "What is the use of cuts at high speed, ripping things to pieces, and then losing all we gain because we cannot cut the time between cuts? To cut your costs properly, you must cut the time between cuts."

One of the most striking characteristics of the properly controlled electric motor, from the standpoint of efficient high speed production, is its ability to operate at widely varying speeds, in accordance with the work in hand, and its ability to maintain a predetermined speed with practical constancy. These characteristics, combined with the ease with which this speed control may be obtained, have opened up vast fields in the application of electric drive to an almost infinite variety of machines.

As an example, take the case of the air supply to a cupola. In the *Electrical Review and Western Electrician* for June 8, 1912, the following statement is made: "The steady melting of iron and the steady descent of the charge from the cupola are dependent on the maintenance of uniform conditions of air pressure." In a recent installation, at the plant of the Canadian Locomotive Co., Ltd., Kingston, Ont., the blower, supplying air to the cupola, is driven by an adjustable speed, direct current motor, the speed being varied by field

control. On the wall in front of the cupola there are mounted a push button, a field rheostat and a draft gage, all located for convenient operation by the man standing on the tapper's platform. The push button is for starting and stopping the motor, and the field rheostat is for regulating the speed of the motor.

It is evident that the man on the tapper's platform not only can start and stop the motor easily, but he can very definitely regulate the speed of the blower and consequently the amount of air supplied to the cupola. This man's energy is directed entirely to the proper melting of iron. He need not worry about the condition of the air supply. If the draft gage indicates an insufficient supply he turns the handle of the field rheostat so as to increase the speed of the blower. And, moreover, he accomplishes the desired results with the minimum of mental and physical exertion.

The trend of modern factory management is toward planning and specifying the manner in which routine work shall be performed, instead of leaving this decision to the judgment of the workman. A recent report of a sub-committee of the American Society of Mechanical Engineers states: "The important questions of speed and feed in connection with machinery operations have, during recent years, been carefully studied by many superintendents and foremen who formerly relied entirely on the judgment of the workmen, which was sometimes good and sometimes bad, speeds and feeds are fixed in the planning department and are based on the power of the machine and the character of the metal." Such a manufacturing policy, is aided by the use of automatic control and the adjustable speed direct current motor. With this equipment, the workman has the selection of a wide range of speeds determined by the setting of the field rheostat. These gradations of speed are much more delicate than can be obtained by the usual mechanical speed changing devices and any given adjustment of the rheostat provides a certain speed which varies but slightly with load conditions. The common practice is to calibrate the rheostat in terms of machine speeds—such for instance as the revolutions per minute of the drill in a

drill press—and then to lay down the rule that for duplicated routine work, the rheostat shall be set at that position which, by careful investigation, has been found most advantageous for the particular job in the machine.

Again, we find a great advantage accruing from having abundant power and maintained speed at the particular place in a machine where work is being done. In this respect, the individually motor driven machine exhibits conspicuous advantages over any type of belt drive. In an article in the *Electric Journal,* A. E. Rickards cites a case in which, in one machine shop, eight drill presses were operated from a line shaft, all of the presses working on the same kind of material and operating continuously for 10 hours each day. All the driving pulleys on the line shaft were of the same size, as were all of the driven pulleys on the presses. Under working conditions the actual speeds of the presses were found to vary from 6 to 39 per cent below the theoretical speed as determined from the ratio of the pulleys. These differences in speed were due to different kinds of belts used and their conditions, which caused various degrees of slippage. The output of these drills was increased 20 per cent by the installation of individual motors, geared directly to the machine.

Another valuable characteristic of the controlled electric motor lies in its ability to repeat definite cycles of operation with unfailing regularity and exactness. For instance, the motor driven reversing planer allows the cutting and return strokes to be at different speeds, either, or both, of which may be varied at will, to suit the needs of different kinds of work, and a predetermined cycle will be maintained exactly, and continuously, until the machine is stopped by its operator. I have just received a report on a planer recently equipped with reversing motor drive. A certain standard piece of work formerly required 6 days; since the planer was equipped with reversing motor drive, the time on the same job has been cut to 3 days.

The controllers for electric motors are not only simple to operate, but they may be located where most convenient and accessible to the workman, or where they will occupy otherwise wasted space. An example of this occurs in connection

with motor drive and automatic starting and stopping as applied to sand mills in a certain steel foundry. The only laborers permanently employed on these sand mills are used for shoveling sand and certainly do not possess any knowledge of electrical machinery. The automatic starters are mounted on columns above the crane runway and the starting and stopping push buttons are placed on the same columns near the floor. The shovelers at the sand mills find it easily within the range of their willingness and ability to start and stop these motors by merely pushing buttons instead of possibly calling on an electrical man or foreman to perform these operations when needed. Easy control of machinery means less difficulty in finding the right man to operate a machine; witness the expensive, important electrically operated cranes of the steel mills, many of them in the hands of foreigners unable even to speak English. Not long ago at the Machine Tool Builders' convention, it was stated that it costs $35 per man to hire him, try him out, and fire him for inefficiency. As an important and unrecognized merit, let the properly controlled electric motor be credited with having made it distinctly easier to find the right man to operate a machine.

With electric drive, individual machines may be shut down when idle, power being taken only by such machines as are in active use; thus overtime work on a few machines, often a pressing necessity, requires only the operation of their respective motors, instead of the waste of power in a long train of shafting, belts and idler pulleys.

Another worth-while advantage of electric drive is the saving in space that may be accomplished and the possibility it presents of allowing machines to be placed to suit conditions of lighting, sequence of operations or easy accessibility to the supply of material. This, in over-crowded plants, often means the possibility of expansion without a heavy outlay in additional land or new buildings. Arrangement of machines to suit lines of shafting is extremely rigid. Electrically driven machines may be placed where desired, from the standpoint of the manufacturing needs. Moreover the arrangement is under no necessity a permanent one—electric drive means flexibility in location and relocation.

The elimination of overhead shafting often allows headroom for traveling cranes, making the handling and transporting of material quicker, safer and less expensive.

Electric motors and controllers can be enclosed and successfully operated in locations of excessive dust and dirt, moisture and fumes, an item of some importance in many shops.

The advantages cited thus far, relate chiefly to cases where a machine is driven by its individual motor, which is selected and controlled with particular reference to the peculiar operating characteristics of the machine. We next consider the motor merely as a source of power, driving the machinery partially or entirely in groups and using a moderate amount of belts and shafting.

The question arises whether electric power should be generated or purchased. Unquestionably, the amount and the proportion of purchased power is rapidly increasing. Inasmuch as this question has been coldly and carefully studied by eminent engineers and executives, it is reasonable to assume that in many cases, it is economical to purchase electric power. Statistics are given concerning the cost of electric power in seven foundries having their own plants, ranging in capacity from 50 to 773 horsepower and driven by both gas and steam engines. The average horsepower per foundry is 228. The average maximum demand per foundry is 141 horsepower. The average cost for producing this power is 3.34 cents per horsepower hour, while the average cost to buy this power at the rates prevailing in the district where the foundries are located, would be 2.02 cents per horsepower hour, a saving of 1.32 cents per unit or 39.5 per cent.

We now come to an important phase of the subject which is difficult to describe or to demonstrate convincingly. I refer to the increase in productiveness and the decrease in accidents due to a quieter and lighter condition in factories, secured through the use of electric motors.

Of late increased attention has been given the health and welfare of the workman. It is rapidly becoming an established belief that better surroundings make for better work, that the

health of the employe has a direct effect on his value as a producer, and that reasonable efforts directed toward the betterment of working enviroment are not only morally and ethically correct, but have their reward in increased efficiency. The electric motor helps not a little toward this desirable end. The partial or complete absence of rapidly moving belts and shafting, with their nerve-affecting, flickering shadows, makes better lighting, less eye-strain, less nervous strain, and fewer errors, with a lessening of defective work and, obviously, ai increased marketable production. Electric drive means purer air, more cleanliness, elimination of distracting noises, and more cheerful surroundings generally. Any reduction in nervous tension, mental effort and physical exhaustion leaves more energy to be applied to the task in hand.

As to the influence of proper illumination on production let me quote from a paper by C. L. Eshleman before the American Institute of Electrical Engineers.

> "Available data shows that an efficient lighting system increases the output from two per cent in steel mills to ten per cent in textile mills and shoe factories. Two hundred and fifty thousand industrial plants in the United States have an annual output of $20,000,000,000. To be ultra-conservative, we will say that there is a saving of only two per cent in the annual output. This means a saving of $400,000,000. This enormous sum represents the saving on actual production and leaves us to conjecture what the saving would be if we took into consideration the improved quality of output and the saving due to a decrease in accidents. Deducting the first cost of installation and maintenance there is still left an almost increditible amount."

From figures published by the Industrial Commission of Wisconsin, a certain steel plant installed an efficient lighting system, and found that the output at night was increased over ten per cent. In order to determine whether this was due wholly to the introduction of better lighting conditions the lamps were taken out for a short period and the work carried on under the old lighting system. It was found that the amount of work fell off over ten per cent. With the re-introduction of the improved conditions the men were again able to exceed their former rate by over ten per cent.

As to the influence of proper illumination on accident prevention, I make the following quotation from *Modern*

Industrial Lighting, published by the National Electric Light Association.

> "The chart, published herewith, tells graphically the story of loss and suffering which result from inadequate light. At the top we see the ratio between darkness, cloudiness, and sunlight in the city of New York. At the bottom is set forth the "curve" of fatal industrial accidents of three successive years as reported from 80,000 industrial plants. Analyze these charts in the light of the statement of the Fidelity & Casualty company that "the greatest number of accidents occur during the months of diminishing light," and it will be acknowledged that illumination is sadly under-rated as a means of accident prevention. It is not, however, lost sight of by those who have much experience in dealing with the legal aspects of accidents. A prominent official of one of our largest manufacturing companies is authority for the statement that "insufficient illumination" is frequently held by juries to be "contributory negligence" and in the defence of accident suits the lawyers of this company make it a point to offer testimony by a competent witness to prove the adequacy of the lighting in this company's plants.
>
> "The subject is not here considered from any humanitarian standpoint: that is something which each manufacturer must face individually.
>
> "We simply point out that each serious accident completely demoralizes a shop; that this demoralization may last for a day or a week; that during this period of distress and excitement the operatives are inefficient and expectant of further trouble; that production drops while spoilage and seconds due to nervousness increase; that the absence of employees is greater and that the whole spirit and morale of the plant is broken down. Facing these facts, we begin to see an economic advantage in accident prevention. As to how to accomplish this most cheaply, the authorities on industrial accidents and safeguards for operatives declare that good illumination would prevent approximately 25 per cent of the avoidable accidents."

It might be regarded as a leap of the imagination to argue, because improper or insufficient illumination dwarfs production and increases accidents, that the absence of motor drive produces the same detrimental results. Undoubtedly such a sweeping statement is unwarranted. Nevertheless, I ask you to make a mental picture first of a factory with its multiplicity of belts, shafting and pulleys casting flickering shadows, and second of a factory with these largely eliminated and the lighting uniform and good. Consider this comparison in the light of the statistically proven effects of illumination on production and accident prevention, and you will probably conclude that

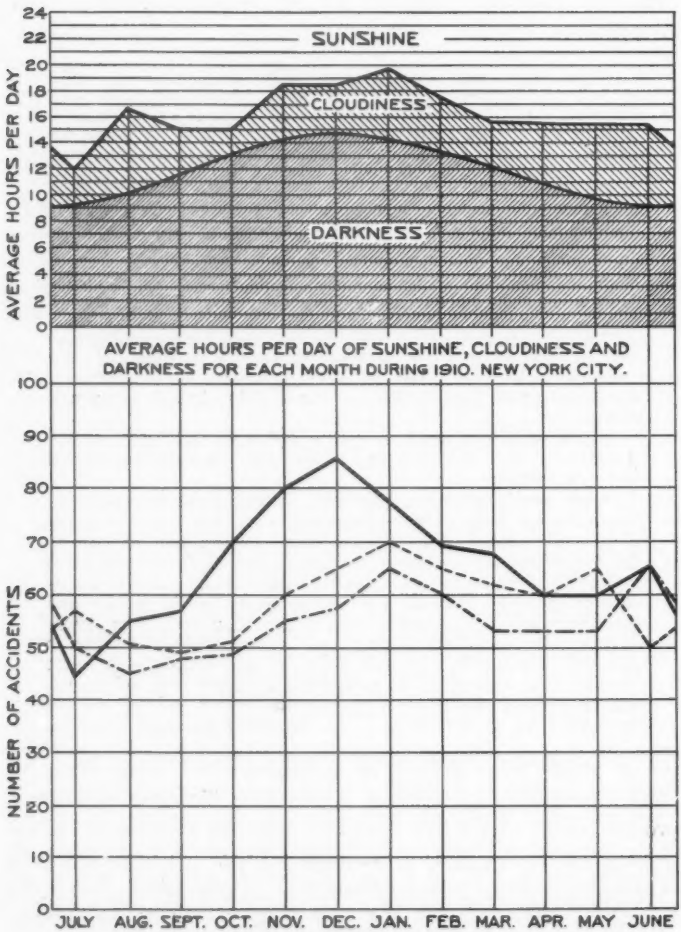
SUNSHINE
CLOUDINESS
DARKNESS
AVERAGE HOURS PER DAY
0
2
4
6
8
10
12
14
16
18
20
22
24
AVERAGE HOURS PER DAY OF SUNSHINE, CLOUDINESS AND DARKNESS FOR EACH MONTH DURING 1910. NEW YORK CITY.
NUMBER OF ACCIDENTS
0
10
20
30
40
50
60
70
80
90
100
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
SEASONAL DISTRIBUTION FOR THREE SUCCESSIVE YEARS OF ABOUT 700 DEATHS ANNUALLY FROM INDUSTRIAL ACCIDENTS REPORTED FROM AN AREA EMBRACING 80,000 PLANTS.

FIG. 2

the use of electric motor drive is apt to increase the productive capacity of the workmen and to diminish the hazard of accidents.

Most of the arguments against the use of electric drive are founded upon the increase in investment which is represented by motors and controllers. Generally speaking the investment in electrical equipment increases with the increase in the economies and conveniences secured by its use. Consider the following assumed installations which are progressively more expensive in first cost and more economical and safe in operation: *First,* the replacement of an engine by one large motor driving the existing line shafting, the motor being started by a manual device. *Second,* the same motor equipped with push button starting and stopping, eliminating the need of a competent or skilled operator. *Third,* the same installation but in addition equipped with rapid emergency stopping by dynamic braking, operative in case a workman is caught in some machine. *Fourth,* several motors driving groups of machinery with a partial elimination of shafts and belting, a certain measure of flexibility of arrangement, and the ability to run or shut down one group of machines independently of the other groups. In addition, such motors may have the three types of control mentioned above. *Fifth,* a constant speed motor individually driving a machine, eliminating belts and shafting, providing the utmost flexibility in arrangement and location of machinery, giving abundant power and maintained speed at the tool, and permitting running of the machine any time it is desired, regardless of other tools. *Sixth,* the same installation equipped with push button starters, insuring the acceleration of the motor in the shortest safe time and making the operations of starting and stopping so basically simple that any one can accomplish them and that no one can perform them incorrectly. *Seventh,* an adjustable speed motor furnishing precisely the desired speed at the machine and permitting speed changes with the minimum of time and effort. *Eighth,* the same installation but equipped with automatic control, so that the operator, by moving a small lever to different positions, can automatically start, stop, or reverse the motor in the shortest safe time. Such an equipment gives the work-

man the highest degree of skill and productiveness. *Ninth,* an equipment of motor and automatic control such that after the proper adjustments are made, the machine regularly duplicates a definite cycle of operation until stopped by the operator. In this, the highest development economically, the mechanism not only performs the work, but, to a large extent, does its own thinking.

It is needless to state that any installation must not be considered merely from the standpoint of first cost; all pertinent fiscal factors must be assigned their proper importance. This paper has accordingly been written in the hope that it may afford some slight assistance in recognizing and evaluating the various economic and technical considerations entering into the subject of electric motor drive.

The Two-Story Foundry

By G. K. Hooper, New York.

I take pleasure in complying with the request of your committee on papers for a contribution covering two-story foundries, as this type of foundry plant seems to be with us to stay. Two, or possibly three different forms have been built. Therefore, a little discussion of their characteristics and differences may prove of interest.

The two-story type of foundry is a natural development of the necessities attending the use of molding machinery. It has for some time been well understood that the molding machine requires much auxiliary apparatus for the development of its full capacity and efficiency.

The large capacity of molding machines naturally necessitates a large amount of floor space, which means handling large volumes of material, specially sand. Conveyors naturally suggest themselves for this work and these necessitate trenches in the floor into which sand can fall or be shovelled after shaking out, a conveyor at the bottom taking the sand to any desired point. It was soon discovered that to give these conveyors the necessary attention and care, the trenches must be increased in size, until finally the designer, in providing for a number of molding machines, found himself practically incurring the cost of a cellar without getting one, so that a cellar under the foundry floor became inevitably the next step. This step, however, was in a false direction, since naturally a cellar is dark and somewhat expensive to construct and incidental to its construction floor space became available which could be put to good use, so that the suggested cellar became a ground story with the molding floor raised up above it and the two-story foundry was then complete as far as general plan is concerned.

A number of two-story foundries have been built and as previously stated, several types exist. Of these, but one seems likely to endure, that is, the one in which the shaken-out sand falls through the molding floor onto conveyors situated under the ceiling of the first story. In this case the floor space on the first story is used for cooling, cleaning and storage of castings with sometimes, core-making and simple finishing operations on some or all of the castings, gravity being used to a great extent in handling castings, etc., from the molding to the first story floor. There are more of this type in existence than all of the other types put together and, in my opinion, it is the type which is destined to endure. It was also the first of the several types to come into existence, the others being variations of it.

Several Two-Story Types

The other types include those in which practically no conveying machinery of any sort is used beyond an elevator for sand at each molding station, the ground floor being entirely given over to cooling, tempering and handling of sand. Much labor is necessary to properly condition the sand and deliver it to the elevators by which it is returned to the molding machines. It is contended that this labor is no more costly than the investment power and maintenance charges of sand conveying machinery. I am sure that this is not the case, while the space occupied for a given tonnage is doubled and the casting loss increased, as the sand can never be as well conditioned by hand as by means of properly designed machinery. Comparatively few foundries of this type are in operation, and in my opinion, this form cannot endure as it is wasteful of space and labor when compared with the first type. Its design originated, I believe, in a mistaken idea of the disadvantages of conveying machinery.

The third type is a combination of the foregoing two in that not only is the lower floor used practically entirely for the storage and conditioning of sand, but much conveying machinery in addition to the elevators is used for this purpose, the whole forming a decidedly costly and wasteful method of

conducting these functions. So far as I know, but one plant of this type has been built; its construction cost was undoubtedly great and its operating cost must be greater than either of the other two. I shall be very much surprised if any are built like it in the future.

Cost of Floor Space Higher

A slight advantage in mold handling is claimed for these two latter designs. Since two-story buildings cost in round numbers three times as much to build as one-story buildings of same ground and type of construction, their floor space costs 50 per cent more than that of a one-story building. This entails, of course, an additional overhead charge which would largely offset any advantage gained through slight increase in labor efficiency.

Several two-story foundries of the first type have been built on the upper stories of the manufacturing plants which use their castings. Such a location makes no essential change in the construction or general arrangement and it does not necessarily follow that the same advantages of handling which exist in the two-story foundry are obtained by superimposing a number of finishing operations with the foundry above them.

The more that operations are superimposed the more complicated are the considerations of space, construction, handling and storage and I can state from direct information as to the comparative handling costs of a two-story foundry located on the ground and one placed on top of the finishing plant, both operating on the same product, that there is no gain in this respect in the superimposing of the foundry upon the rest of the plant. It is noticeable that a prominent concern now using several superimposed foundries is building its newest one on the ground, although of the two-story type.

All of the two-story foundries in existence are operated on the continuous system which is, of course, another logical consequence of the use of molding machinery with its attendant devices. The molding operations are conducted by a number of different methods. Sometimes the gang system is used,

short floors being utilized for placing the molds which are then poured either by a pouring gang or by the mold maker. In the latter case the iron is brought to the molder by a ladle gang, after which a shaking-out gang takes charge of the molds and separates sand, castings, equipment, etc. Another method of operation is continuously by means of a mold conveyor, no "floors" being used in this case. Sometimes the two above methods are united in one building where the production will permit. I have made designs for all of the above methods.

A general review of my records of the operation of two-story foundries indicates that the floor space required for molding, casting and shaking-out is somewhat less than one-third of that required for the same class of work in the one-story, one-heat foundry.

In my paper on continuous foundries, written for the Buffalo convention of 1912, is made the statement that the floor space required for continuous operation, is less than one-half that required for single heat operation. That has proved to be a conservative statement since later experience and study show the saving, as stated above, to be greater than this.

Floor Space Varies

Areas vary considerably with varying classes of work as will be evidenced by carefully compiled figures published by *The Foundry*, which show that in American practice a space of from 400 to 850 square feet per ton, per day, is used in one-story foundries for differing classes of work. I have had a case in hand in which the relative area figured out almost exactly one-third of the present floor space and another where the change from a one-story building operating two heats per day to a two-story plant, operated continuously of course, made a reduction of 36 per cent in the floor space used, which practically confirms the one-third or, 33 1-3 per cent figure, as compared with operation at one heat, per day.

The castings in the above cases averaged 70 per cent of the melt.

If the cooling and cleaning operations should balance up in time and space with the molding, pouring and shaking-out, the best type of two-story foundry, exclusive of the raw material yard, could then be built on about one-third of the ground space occupied by a one-story, one-heat plant.

This great reduction of area is, of course, not entirely available since in one story, one heat operation, cooling goes on at night thus consuming no time nor space during the operations of the day, while the cleaning operations are usually spread over the entire working day and thus do not balance up relatively with the molding, casting and shaking-out. These features tend to increase the relative ground space to something higher than the previously noted percentage, but on the other hand, storage, simple finishing operations on part or all of the castings, and sometimes coremaking, can be united in the two-story plant thus making a saving in floor space elsewhere in the plant which should be credited to the two-story design.

It seems safe to say, therefore, that two-story foundry plants can be constructed for such work as lends itself properly to handling in this way, on from 120 to 200 square feet of ground area per ton of castings, per day, exclusive of storage of sand, metal and fuel.

General Construction

The buildings for the two-story foundry should be preferably of brick and steel construction with fireproof roof and floors. The wearing surface of the floors preferably should be of repressed shale brick.

The width of the building, if pouring and shaking-out are handled by separate gangs, will vary from 70 to 90 feet, depending upon the size of the mold, this providing a floor of suitable length on either side of a central bay, which latter is used for shaking-out and as a general passage for ladles, patterns, cores, etc. This arrangement will bring the molding machines or benches at the windows. Should a mold conveyor be used, the building can be narrowed. The length of building

bay along the well should be about 16 feet. This gives plenty of room for floors for molds which must be handled by a light crane or an overhead monorail traveler and permits as well the doubling of snap floors, it being possible to put two such in a bay of the above width. The molding floor should preferably be free from columns, all overhead apparatus such as conveyors, cranes, monorails, carriers, etc., being supported on the roof trusses. Columns are no objection on the first floor. Their spacing should, however, be as great as suitable accommodation for the apparatus used there will permit. This spacing, however, will be largely predetermined by the width of bay adopted for the molding and casting floor.

A roof of considerable pitch with large monitor, is predicated in order to insure ventilation and light. A live load of 275 pounds per square foot is sufficient for the molding and casting floor, save in the cupola bay where special supporting arrangements must be provided. Window area is made a maximum with maximum opening for ventilation. Such a building costs in the vicinity of New York about $2.60 per square foot of floor area.

The benefits gained by two-story foundry construction are those of continuous operation, since without handling machinery two-story construction would be unnecessary and with handling machinery continuous operation by some method is predicated in order that the increased overhead charges may be diminished to the greatest extent.

I will quote therefore from my paper on continuous operation previously noted. I still have a few copies for those who may desire to have one:

> The average increase of efficiency of foundry labor, due to the introduction of continuous methods, is about one-third. As a result of the study of foundries on work which can advantageously be done by continuous methods, it has been found that the efficiency of well conducted hand-operated foundries, though varying considerably, averages about 50 per cent with a possible maximum of 55 per cent. This means that the men do about half of the useful work which it is theoretically possible for them to do.
>
> "In the conveyor foundry, the average efficiency is about 65 per cent with a possible maximum of about 70 per cent. There is

thus possible an average increase in labor efficiency of about one-third, with a possible maximum increase of about one-half. There are few, if any, continuous systems operating at higher than 70 per cent, and this represents about the best plant efficiency in my opinion, of which the foundry is capable today. Perhaps the permanent mold when in successful general operation will increase this somewhat. The above figures are, however, large enough to be interesting to the foundryman. To be able to get out his present production by the use of about three-fourths of his men or to increase his production about one-third with his present force, is with its collateral advantages, an attractive proposition.

Another point of saving is in the investment in individual equipment, this diminishes in direct accordance with the reduction in number of operatives. The foundry loss is also diminished being reduced in some instances to one-half the percentage of that shown by operation in which the molder pours his own molds. One-third less loss is, however, a more representative figure.

Briefly the various advantages of the two-story foundry, are, therefore, less ground space, higher labor efficiency, decreased foundry loss and reduction in total cost of molding equipment. The sum total of these when applied to several differing lines of work has made a favorable showing on the right side of the ledger. Investigation will doubtless show that the same can be done in other classes of work.

Molding Sand Tests

By Dr. Richard Moldenke, Watchung, N. J.

Much has been written on the subject of molding sands for foundry use, and many tests have been made by eminent geologists and foundry experts. The field is therefore not a new one even though it is neglected by those whom the investigations should serve most, namely the foundrymen. Molding sand is so cheap a commodity that comprehensive investigation into the fitness of available sands is rarely made by the producer of castings. He is extremely surprised when talked to on the subject, to learn that of given sands of practically the same cost, one will turn out four tons of castings per ton of sand, and another four times this amount for the same classes of castings.

Realizing that molding sand is one of the elements making up the foundation of the foundry business, the Association undertook to make a series of tests on the various properties of this material, the summary of which, as far as carried out, is given herewith.

Molding sand is used to form a container for molten metals or alloys. Hence it must be non-yielding, porous—that is permeable to gases and air,—and the mold must be readily destroyed after using. Molding sands must hence be highly refractory, give a fine surface to the castings, bond well and vent readily.

Before going into the details of the tests, it may be mentioned that the conditions under which the samples were received from the generous donors were that names should be kept confidential. While in a number of cases the sands were received with no such restrictions, it is better in making comparisons of the several sands from results given in the tables, that some idea be had as to the locality of the samples, as this conveys a better impression to the foundryman in comparing with his own foundry sands. Hence the following divisions may be given, allowance being made for the fact that some sand merchants represent various sections of the country with

their marketable products. (See tabular matter,* Natural Molding Sands labeled "A", "B", "C", etc., see also foot note.)

Geographical Divisions.	Reference Letters in Tables.
Albany region sands.	D, F, L, O.
Kentucky sands.	B, P.
Ohio sands.	C, H, N, R.
New Jersey sands.	U, Z.
Pennsylvania sands.	M, W.
Missouri sands.	G, T.
Illinois sand.	V.
Georgia sand.	X.
Tennessee sand.	Y.

No confidence will be violated in stating that the peculiar molding sand U, which is interesting from many standpoints, comes from Metuchen, N. J., as it was dug up by the author himself, and is not available for the foundry at the present moment, though when used, proved excellent.

The letters of the alphabet used in the tables and not given above refer to sands either from localities unknown to the author, or where unimportant to the foundry industry in general.

As this summary is written for the use of foundrymen, it will be unnecessary to attempt to instruct the layman regarding the uses of molding sands in general. The foundryman, however, will be interested in the manner in which nature has prepared the sands he uses, and hence is referred to the able exposition of the subject in the pamphlet by Mr. D. Dale Condit —page (3) of the tabular matter. Mr. Condit, through the courtesy of the Ohio State Geological Survey, made an examination of the mineral characteristics of all the sands received, and which will be referred to later on in discussing the refractory properties of the material at issue.

The first thing which will be of interest is a study of the composition of the molding sands. We know them to be serviceable in the foundry as practically all of them are in daily use. It will be interesting to see whether anything can

*The tabular matter referred to in this paper was published in the Transactions of the A. F. A., Volume XXI. The page numbers given in parenthesis refer to those printed on the bottom of the pages in question.

be learned from the composition of the sands which would be of value in judging new candidates for foundry favor.

Two Methods of Determining the Composition

Here we run into two methods of determining the composition which are current. In the case of an ultimate chemical analysis, which gives the percentages of the elements present, regardless of their juxtaposition. For instance, we would get such an such a percentage of silica, aluminum, lime, iron oxide, soda, or potash, but not whether as a silicate of alumina (clay), or the free silica (quartz) independent of the silica of the clay, etc.

In the case of a rational analysis of the sands, we differentiate the free quartz, the clay substance, and the undecomposed feldspars—thus going back to the original granite, from which these molding sands came through the weathering of the ages. The quartz is the sand proper. The clay substance is the bond. The undecomposed feldspar carries the fluxes which damage the refractory properties of the molding sands in question.

For the purposes of these tests the rational analysis only was considered, and the results are given on page (68) of the tabular matter. The work was generously given by Mr. H. E. Field, then connected with Mackintosh, Hemphill & Co., of Pittsburgh.

In order to get a fair idea of the composition of the molding sands of the several regions enumerated above—at least where a number of samples were available, the following averages have been calculated:

Region.	No. of Samples.	Quartz. Per cent.	Clay Substance. Per cent.	Feldspar. Per cent.
Albany	23	58.82	18.99	22.16
Kentucky	13	64.53	24.77	10.69
Ohio	14	71.02	23.79	5.17
New Jersey	4	81.38	15.49	3.13
Pennsylvania	9	67.21	21.99	10.79
Missouri	10	64.10	24.36	11.54
Illinois	1	70.82	16.65	12.53
Georgia	1	77.37	17.94	4.69
Tennessee	1	74.53	21.11	4.36

A grand average of the 76 samples in the foregoing list is of interest solely in roughly estimating the chances of a new sand to be considered for foundry purposes at all. This grand average is as follows: Quartz, 65.53 per cent; clay substance, 21.73 per cent and feldspar, 12.74 per cent.

For those who are accustomed to the ultimate chemical analysis of molding sands instead of the rational analysis, the above grand average has been recalculated, as follows:

Silica	84.26
Alumina (and Iron Oxide)	13.59
Alkalies	2.15
	100.00

A glance at the figures given in the table above shows that there are some pretty wide variations in the make-up of the several sands. Thus, the quartz, or sand proper, runs from 58.82 all the way up to 81.38, the latter having very little bonding material—which consequently must be very rich to be of any value. On the other hand, the clay substance, or bonding material, runs from 16.65 up to 24.36; while the dangerous ingredient, or the undecomposed feldspar, which is fusible at high temperatures, such as exist when iron is molten, runs as high as 22.16 per cent in the Albany sands. This fact accounts for the almost universal use of the Albany sands for very light work. The iron sets almost as poured, and hence the fusibility of the feldspar has no chance to come into play.

Some of the molding sands show very fine figures for this fluxing percentage, it running as low as 3.13 in the average given above.

Grain Size

To see whether any special difference is to be noted in the rational analysis of molding sands, as these may be affected

by their size of grain, the following classification has been worked out from the tables:

Fine Sands

(Correspond to 90 to 100 per cent fineness—see tables)

Region.	No. of Samples.	Quartz. Per cent.	Clay Substance. Per cent.	Feldspar. Per cent.
Albany	4	60.13	17.34	22.53
Kentucky	8	63.88	23.33	12.78
Ohio	2	72.98	22.75	4.26
Pennsylvania	2	62.13	20.47	17.39
Missouri	2	60.80	28.71	10.48
Average of	18	63.53	22.22	14.26

Medium Sands

(Correspond to 80 to 90 per cent fineness—see tables)

Region.	No. of Samples.	Quartz.	Clay Substance.	Feldspar.
Albany	6	60.52	16.39	23.09
Kentucky	1	59.06	29.80	11.14
Ohio	1	78.03	18.28	3.69
Pennsylvania	2	63.36	19.26	17.38
Average of	10	62.69	18.49	18.81

Coarse Sands

(Correspond to everything below 80 per cent fineness—see tables)

Region.	No. of Samples.	Quartz.	Clay Substance.	Feldspar.
Albany	13	57.65	20.71	21.64
Kentucky	4	67.19	26.41	6.39
Ohio	11	70.03	24.49	5.47
New Jersey	4	81.38	15.49	3.13
Pennsylvania	5	70.78	23.69	5.52
Missouri	8	64.93	23.27	11.80
Illinois	1	70.82	16.65	12.53
Georgia	1	77.37	17.94	4.69
Tennessee	1	74.53	21.11	4.36
Average of	48	66.87	22.22	10.98

A comparison of these figures indicates that with few exceptions, whether a sand be coarse or fine, it seems to carry the same proportions of bond and fluxes.

Attention may be called at this point to the very elaborate analyses of all the sands for their mineral constituents, as seen under the microscope. (See tables, page 12, of the original investigation.) One would hardly imagine that so many minerals could be found in what is a comparatively clean material. Particularly the examination of sea sand taken from Perth Amboy, N. J., with 19 distinct mineral species to its credit, shows what peculiar conditions are encountered in such an investigation.

Apart from the refractory qualities of a molding sand, its bonding power is a most important feature. If copes drop, or the sand is readily cut by the stream of molten metal, it is a sign of either too little clay bond, or this clay not properly distributed; or that the bond is not strong enough for a proper amount of clay well distributed. From this it will be seen that the quality of the clay substance in the rational analyses given is a most important item.

A good sticky clay is called a "fat" clay. A poor clay, which will not stick together when wet is called a "lean" clay. The laboratory method of distinguishing between these, and to rate the degree of fatness, is to add a definite amount of a brilliant dye to a definite amount of sand in a definite volume of water. After a standard manipulation, which will not be of interest here, the fat clays will be found to have absorbed much larger percentages of the dye than the lean ones, and a quantitative test can thus be made. While the tests as carried out are not as accurate as they would be by a new method since devised, the figures are nevertheless quite valuable. They are given on page (106) of the tables.

To get at the relative value for bonding power of the clay in the sands investigated, the following table has been calculated. Here we have first, the percentage of dye absorbed per unit of clay contained in the several sand regions, as averages. Next, the actual clay percentages, as averages and taken from a previous table. Finally, the relative bonding value, the Albany region clay being taken as the unit, this being the poorest:

Region.	No. of Samples.	Per cent dye absorbed per unit of clay.	Clay bond averages.	Relative bonding value.
Albany	23	3.27	18.99	1.0
Kentucky	11	5.19	24.77	2.0
Ohio	14	5.73	23.79	2.2
New Jersey	4	7.00	15.49	1.7
Pennsylvania	9	4.09	21.99	1.4
Missouri	10	5.82	24.36	2.3
Illinois	1	8.89	16.65	2.6
Georgia	1	4.96	17.94	1.4
Tennessee	1	6.53	21.11	2.2

This table is instructive, as it shows how variable the bonding power of the several sands turns out to be when subjected to a close investigation. As stated previously, recent improvements in the method of dye absorption for valuing clays (as gotten up by Saunders & Franklin) show up the situation even plainer, the fat clays absorbing more of the dye selected and the lean clay proportionally less.

While unfortunately the three last regions of the series are represented by but one sand each, yet the two with the high bonding power gave eight to ten tons of casting of fairly heavy section, to the ton of new sand used in the daily strengthening up of the sand piles. For similar work, the sands with low bonding power gave only half as much, indicating that the test made is a very fair exposition of the situation.

Next comes the question of size and shape of the sand grain. As a general proposition the smaller the grain, the finer the surface of the casting. The investigations made were therefore extended into the grain conditions of the sands. A number of things have a bearing on this matter. The question of round or angular grains, large or small sizes, and whether uniform in size or widely varying. Elaborate studies have been made along this line by many investigators, to observe how nearly the natural sands correspond to a theoretical manipulation of different sized spheres bunched together in several ways.

The general conclusions are that sands with grains of every size mixed together are not as good as sands with a uniform grain size. In the case of the former, the smaller particles fill in the voids between the larger ones, and thus reduce the venting power. Again, while the angular grained sands pack tighter, and hence give stronger values, the packing does not extend inward as far as with sands of rounder grain. This is perfectly evident, as the chance of movement under a blow is not as great.

Theoretically there is the same percentage of venting space between round grained sands of small size as between large ones. Practically, the question of friction between the grains and the air or gases moving about them means that where

heavy masses of iron are to be cast, a mold of very fine sand would not take off the gases fast enough once they can no longer escape through the risers. If the matter is complicated by angularity on the part of the grains, it is very easy to see that too hard ramming can quickly spoil a mold made of sharp molding sand, while the rounder grained varieties are not in such danger. On the other hand the sharper sands will hold up better for this reason, and hence need less clay bond. It is safer, however, to work the other way, and hence an ideal molding sand would be the one which has perfectly round grains of a size suited to the thickness of casting to be made. Each grain in this ideal sand to be coated with as thin a layer of as rich a clay as possible, the clay to be of a highly refractory character. Such a sand, not yet found in nature, but perfectly possible of making artificially, would be truly "fool proof."

In studying the tables of fineness of sands, page (75), we are struck with the fact that the finer varieties run more uniform than the coarse ones. That is to say, there do not seem to be very serious admixtures of large particles in the former sands, while the coarse sands have their voids filled up with quantities of finer particles. To get at this more in detail, the following tables have been worked out, in which the sands have been divided into regions as before, and the same divisions as to fine, medium and coarse sands, taken:

Fine Sands

(Between 90 and 100 per cent fine)

Region.	No. of samples.	Per cent over 20 mesh.	Per cent between 20—40.	Per cent between 40—60.	Per cent between 60—80.	Per cent between 80—100.	Per cent under 100 mesh.
Albany	4	.03	.60	1.19	1.26	1.81	95.09
Kentucky	8	.03	.09	3.43	3.26	3.41	89.78
Ohio	2	.04	.14	5.54	6.63	6.34	81.26
Pennsylvania..	2	...	.54	2.20	4.88	4.92	87.96
Missouri	2	.02	.34	6.22	4.50	2.64	86.28
Average of..	18	.03	.29	3.33	3.51	3.46	89.42

Medium Sands
(Between 80 and 90 per cent fine)

Region.	No. of samples.	Per cent over 20 mesh.	Per cent between 20—40.	Per cent between 40—60.	Per cent between 60—80.	Per cent between 80—100.	Per cent under 100 mesh.
Albany	6	.87	5.84	8.08	11.17	20.99	66.62
Kentucky	1	...	.08	10.52	8.60	9.00	71.80
Ohio	1	.04	.32	7.36	11.56	11.48	69.24
Pennsylvania..	2	.02	1.14	9.90	13.28	11.56	64.10
Average of..	10	.53	3.75	7.92	10.96	16.96	66.90

Coarse Sands
(Below 80 per cent fineness)

Region.	No. of samples.	Per cent over 20 mesh.	Per cent between 20—40.	Per cent between 40—60.	Per cent between 60—80.	Per cent between 80—100.	Per cent under 100 mesh.
Albany	13	1.80	18.66	22.06	15.37	10.19	31.96
Kentucky	4	.27	12.86	21.40	14.07	9.76	36.94
Ohio	11	1.38	15.36	10.83	16.26	7.01	29.16
New Jersey..	4	8.64	27.14	26.02	15.40	7.61	15.19
Pennsylvania..	5	.19	7.31	39.25	15.88	8.95	28.43
Missouri	8	.53	20.69	21.10	13.62	6.60	38.69
Illinois	1	2.56	39.60	34.16	5.52	1.36	16.80
Georgia	1	.08	.24	36.00	14.48	15.36	33.84
Tennessee ...	1	7.20	25.76	38.96	10.48	4.48	13.12
Average of..	48	1.83	17.69	28.95	15.32	8.29	30.40

The observation made above on the lack of uniformity of the coarser sands is fully borne out, for on glancing at the averages of the fine sand tables, one notes how small a percentage of coarser particles are to be found mixed in with the 90 per cent of the very fine constituent.

The medium sands are already poorer in this respect, one third of the total percentage being below the 100 mesh item. Still, adding the material from 60 mesh upward together gives a pretty fair situation.

In the coarse sands, however, we note the heavy bunching between 40 and 80 mesh, which would be satisfactory if 30 per cent of the sand were not above 100 mesh, and hence assists in filling up the voids and hindering proper venting.

The foregoing tables should stimulate investigation on the part of the molding sand merchants. It would seem as if machinery could be designed to separate the dried sand into sizes—or if this would remove the bond, sufficient dampness could be retained to prevent such action. The advance in the times will eventually compel greater attention to the surface condition of castings, which in turn means the condition and quality of the molding sand used. Apart from refractory qualities and a good bond, the grain size of a sand is most important in this respect. One has but to hear the opinions of foundrymen, often expressed in forcible terms, when unloading a car of molding sand—just as it was dug from the bank. What with uneven distribution of the clay, rootlets of trees, and occasional pebbles, lumps of earth, etc., the purchaser would gladly pay an additional price, to get an even and uniformly good article.

An examination of the micrographs of the sand—pages (37) *et. seq.* generously contributed by Mr. H. C. Loudenbeck, of the Westinghouse Air Brake Co., will repay the time spent on them. The remarkable regularity and roundness of the Albany fine varieties stand out prominently. Evidently this sand must have been subject to wave action and the grinding of grain upon grain, to get such a structure. The Kentucky sands show similar, though not so marked features, while the fine sands of the other regions are not as regular or uniform in grain size.

The medium sized sands show the same characteristics—the Albany sands being quite in the lead. In the coarse varieties, the Ohio, Missouri and Pennsylvania sands stand out specially well, otherwise there is much irregularity to be seen.

While many of the sands in question show much irregularity in structure and hence may have to do with the general reputation for poor surfaces that American castings have, it must be remembered that this country is rather prone to overlook unessential matters. Paint covers a multitude of sins, and no part of a casting is machined merely to have the job look neat. Herein we differ from Europe, and hence we have

not given attention to the sand question as we really should. Note, for instance, the magnificent work put out by Belgian foundries, where the sand is highly expensive, and is looked after most carefully. France, Germany, and finally England, pay special attention to sand preparation with consequent good results.

Two things should be kept in mind in the preparation of molding sand for floor work. First, in grinding it, mix new and old sand well and to reduce occasional large grains to the size of the rest. Second, thorough incorporation and dissemination of the bonding clay is necessary. In some European foundries, every shovel full of molding sand from the floors goes through the grinding mills daily, and hence there is no loss from castings where the runner boxes of the molds have been made from sand scooped off the gangways — where notoriously burnt sand from the piles of castings stacked up daily has found lodgment.

While on the venting question, mention should be made of the series of tests on the permeability of sand to the passage of air under light pressure. The method adopted is fully described on page (96). In these tests, as well as those for crushing strength of columns of rammed sand, and also transverse tests of bars of similar material, it was necessary to use three degrees of dampness, the clay bond of some sands requiring more water to temper them properly than others. Hence a 5, 7½ and 10 per cent water addition was adopted, this being found to cover all cases in one way or another so as to get shop conditions. Therefore, while one of the additions might have left the sand too dry, the other two would give sufficient water, and *vice versa*. The unit employed in the permeability tests was the time it took to drive one gallon of air, in a ¼-inch pipe, through a cake of the dried sand 1 inch thick, under a pressure corresponding to a 7-inch head of molten metal. This time is over and above that which would be taken for the gallon of air to pass out of the apparatus free. A summary of the figures

given in the tables follows herewith; the same regional and fineness divisions are used as given in the preceding tabulations:

Fine Sands
Time in Minutes

Region.	No. of Samples.	Dry Sand.	5 per cent Moisture.	7½ per cent Moisture.	10 per cent Moisture.
Albany	4	1.31	1.31	1.19	1.44
Kentucky	8	1.47	1.91	2.16	3.78
Ohio	2	.88	2.50	2.50	2.88
Pennsylvania	2	.88	.88	.88	1.25
Missouri	2	1.38	1.25	1.38	2.50
Average of	18	1.29	1.65	1.75	2.71

Medium Sands
Time in Minutes

Region.	No. of Samples.	Dry Sand.	5 per cent Moisture.	7½ per cent Moisture.	10 per cent Moisture.
Albany	6	1.04	.66	.87	1.08
Kentucky	1	.75	.50	1.00	.75
Ohio	1	.75	.75	.75	1.00
Pennsylvania	2	.75	.75	.75	.88
Average of	10	.93	.68	.85	1.10

Coarse Sands
Time in Minutes

Region.	No. of Samples.	Dry Sand.	5 per cent Moisture.	7½ per cent Moisture.	10 per cent Moisture.
Albany	13	1.27	.77	.89	1.18
Kentucky	4	1.06	.94	1.06	1.38
Ohio	11	.84	.98	1.00	1.14
New Jersey	4	2.38	1.25	2.00	3.38
Pennsylvania	5	1.95	1.10	1.90	2.23
Missouri	8	1.19	1.03	1.31	1.88
Illinois	1	.50	.50	1.50	3.25
Georgia	1	2.00	1.00	3.25	3.25
Tennessee	1	2.75	3.00	4.00	5.00
Average of	48	.97	.89	1.34	1.79

It will be noticed that dried sand allows the passage of air through it better than the tempered article—excepting where only 5 per cent water had been added for tempering purposes. Possibly this comparatively slight water addition served to attach the lighter particles to the others and thus take away some frictional resistance. Where larger amounts of water were used, as for instance 10 per cent, which gave very wet sand for some samples, the obstruction to the passage of air was very marked.

As the sand blocks for these permeability tests were made under ramming conditions equivalent to ordinary squeezer work, it will be seen that where very heavy ramming is resorted to, opposition to the passage of air and gases would be further increased, and the iron would not lie to the mold properly. Hence the universal observation that a casting continually lost in green-sand may be readily made in dry-sand, and the modern tendency is in that direction on general principles.

A further point should be observed, however, and that is that the table preceding should be studied in connection with further summaries relating to the strength of the sands under transverse and crushing pressures. Hence these tables are given below and will show just what degree of moisture gave the strongest work. The classification of the sands is the same as given previously.

The transverse strength of the sands was obtained by weighting one-inch square bars at the middle, on supports 4 inches apart. Weight given in pounds. See page (81) of tabular matter.

The crushing strength was obtained on columns of sand one inch square and 2½ inches high. Weight placed on top, and given in pounds. See page (89) for full description of the tests.

TRANSVERSE STRENGTH

Bars 1 inch square on supports 4 inches apart. Weight in pounds.

Fine Sands

Region.	No. of Samples	Dry Sand.	5 per cent Water.	7½ per cent Water.	10 per cent Water.
Albany	4	1.16	.20	.22	.11
Kentucky	8	1.31	.19	.17	.19
Ohio	2	1.98	.15	.04	.08
Pennsylvania	2	1.20	.16	.09	.06
Missouri	2	.69	.16	.21	.20
Average of	18	1.28	.13	.16	.15

Medium Sands

Region.	No. of Samples	Dry Sand.	5 per cent Water.	7½ per cent Water.	10 per cent Water.
Albany	6	1.49	1.00	.17	.10
Kentucky	1	2.65	1.20	.89	.25
Ohio	1	2.08	.13	.00	.00
Pennsylvania	2	1.55	.17	.14	.14
Average of	10	1.68	.76	.22	.11

Coarse Sands

Region.	No. of Samples	Dry Sand.	5 per cent Water.	7½ per cent Water.	10 per cent Water.
Albany	13	1.57	.29	.15	.12
Kentucky	4	1.18	.58	.57	.38
Ohio	11	2.29	.50	.38	.24
New Jersey	4	1.65	.64	.37	.40
Pennsylvania	5	2.30	.50	.45	.24
Missouri	8	2.00	.34	.28	.20
Illinois	1	3.74	.20	.10	.57
Georgia	1	1.39	.20	.40	.50
Tennessee	1	.87	.56	.30	.15
Average of	48	1.88	.42	.31	.24

CRUSHING STRENGTH

Bars 1 inch square and 2½ inches high. Weight in pounds.

Fine Sands

Region.	No. of Samples	Dry Sand.	5 per cent Water.	7½ per cent Water.	10 per cent Water.
Albany	4	9.62	2.79	2.94	1.96
Kentucky	8	7.41	3.01	3.07	2.74
Ohio	2	6.94	4.66	2.34	2.02
Pennsylvania	2	9.59	2.14	3.47	1.97
Missouri	2	4.93	3.05	2.76	3.42
Average of	18	7.82	3.11	2.97	2.48

Medium Sands

Region.	No. of Samples	Dry Sand.	5 per cent Water.	7½ per cent Water.	10 per cent Water.
Albany	6	9.82	3.08	3.28	2.35
Kentucky	1	27.40	9.75	4.63	3.85
Ohio	1	18.15	5.84	2.58	1.30
Pennsylvania	2	16.24	3.09	2.96	2.26
Average of	10	13.70	4.03	3.28	2.38

Coarse Sands

Region.	No. of Samples	Dry Sand.	5 per cent Water.	7½ per cent Water.	10 per cent Water.
Albany	13	12.92	3.92	2.95	2.37
Kentucky	4	18.69	8.50	6.56	8.06
Ohio	11	12.28	5.67	4.57	4.80
New Jersey	4	16.93	3.22	2.44	2.16
Pennsylvania	5	23.01	5.36	3.31	3.21
Missouri	8	10.60	3.52	2.83	3.24
Illinois	1	30.80	5.89	2.95	7.24
Georgia	1	4.32	2.80	2.70	1.58
Tennessee	1	5.22	7.92	5.03	.93
Average of	48	14.29	4.82	3.43	3.68

In the transverse strength table, it will be noticed that the dry sand results vary much more than do the tempered ones. Similarly in the case of the crushing strength. The fine sands show little difference in their transverse strength when tempered, in fact all are very weak for the size and shape of the bars tested, though good when dried. Since the permeability of these sands is better when little water is used, it is advisable not to wet fine sands too much when tempering. This is the case in foundry practice, as no one using very fine sands—that is making very light castings—would think of wetting down the sand any more than is absolutely necessary. Hard corners in castings would be the result and the machine shop would be heard from.

In the case of the medium sands the diminution of strength when large water percentages are used is even more marked. In the case of the Ohio sand sample it was impossible to lift the test bar when tempered with more than 5 per cent water. The loss in permeability as wetness increases is also quite marked.

The coarse sands are a little better in this respect, as they give averages for strength which show them to be useful with a smaller degree of care in tempering. If too wet, however, they also lose in permeability very quickly.

The question of strength is naturally greatly affected by the bonding value of the clay content, and some remarkable results were obtained, particularly in crushing strength. These points are best seen in the tabular matter when studied in detail. The value of the bond has, however, been worked out in the following table, for comparison between the fine, medium and coarse sand varieties. Hence direct comparisons can be made between clay bond and strength of test bars made of the sands. The figures give the bond value, the average of all the Albany sands being taken as unity.

The bonding value of the three degrees of fineness in the case of the Albany sands is practically identical. It is rather better in the case of the other sands for their coarser varieties. This indicates that the lighter percentages of water are suffi-

cient to give effect to the bonding clay, for in spite of the fact that the bonding value of the coarse sands is higher, when heavy percentages of water are used for tempering them the strength of the sand test pieces is lower.

It is to be regretted that time was not available to study all the sands investigated under high temperatures, as a number of points might have been thus observed. The point of dissociation of the combined water in the bond, the action of heat on the sand grains, the conductivity of one sand as compared with the others as a guide to the possible loss as "burnt sand", etc.

VALUE OF CLAY BOND

Albany total averages taken as Unity

Region.	Fine Sands.	Medium. Sands.	Coarse Sands.
Albany	1.00	0.98	1.03
Kentucky	1.53	1.51	1.78
Ohio	1.21	1.19	1.91
Pennsylvania	1.07	1.13	1.38
Missouri	1.56	....	1.83
New Jersey	....	....	2.14
Illinois	....	....	2.72
Georgia	....	....	1.51
Tennessee	....	....	2.00
Averages (calculated for respective number of samples)	1.33	1.09	1.62

It is to be hoped that the information obtained from the A. F. A. tests summarized herewith may be of use to the foundry industry, and stimulate foundrymen to a closer study of their sands, so that a smaller quantity may go as far as the larger one does now. Further, the sand merchants should improve their product by systematic grading and incorporation of the clay bond. Better results will thus be obtained and the stigma of poor looking castings removed from the American foundry industry.

Coke Recovered from the Cupola Dump

By W. J. KEEP, Detroit

It is common practice among foundrymen to take the half-burned coke from the cupola drop and to let the man on the charging platform use it as he pleases without weighing. As it is water-soaked the weight would not be correct and as it has been weighed once, it should not again be charged against the cupola fuel consumption. It is desirable, of course, to charge no more iron and coke than is necessary to make the last iron good. At best, considerable iron will remain unmelted or will be cast in the pig bed. A corresponding amount of coke will be left over, but much of this fuel is burned by the sharp blast and hot cupola at the end of the heat. The best practice is to decrease the coke on the last three charges and frequently the last charge of iron can be melted without the addition of coke, the heat in the cupola walls being sufficient to melt the iron. The coke left over is not considered of much value and it certainly does not appear to have much fuel value.

In the production of a certain grade of iron, it was found desirable to have the sulphur run as low as possible and the cars of coke containing exceptionally low sulphur were saved for that purpose. When we previously used Connellsville coke it was considered desirable to have the ash content about 10 per cent so that the coke would satisfactorily carry the weight of the burden. Rarely was the sulphur less than 0.75 per cent and frequently it was 1 per cent or more. The by-product coke which we are now using has a firm structure and a low percentage of ash. One morning it occurred to me that the burned coke should be high in ash and low in sulphur and if so, it should be charged on the bed. I took samples of by-product coke

from the car from which the half-burned coke was taken and sent it to the producer to obtain the opinion of his chemist to ascertain the analyses of both the burned and the unburned coke.

He reported that the partially-burned coke is higher in ash than the average coke and for that reason would not be quite so good for melting iron. On the other hand, it is lower in sulphur than the unburned coke and for this reason it would be more desirable for melting iron than fresh coke. Apparently the sulphur is imparted to the iron in a gaseous state and not from the molten or slag state. If the burning coke is not disturbed, the coke holds its original shape fairly well, retaining the ash as the carbon burns out, but in a cupola, the chemist ventured the opinion that the burden and the movement downward would have a tendency to separate the ash somewhat from the coke during burning.

Chemist's Reports

The report of the chemist follows:—A sample of coke was obtained from the ovens containing 7.40 per cent ash and 0.902 per cent sulphur. Several pieces of this coke, about nutmeg size, were weighed, placed in a platinum dish and heated in a muffle about 1 1-2 hours. Nearly two-thirds by weight of the coke was consumed, the volume remaining nearly the same and very little of the ash fell off while the coke burned, if it remained undisturbed. The unburned portion of the partly burned coke contained 8.86 per cent ash and 0.706 per cent sulphur. The ash from the burned coke contained 0.152 per cent. The weight of the pieces taken was 20.4419 grams, the amount burned off was 13.2741 grams and the unburned coke left weighed 7.1673 grams. The ash balance follows:

Grams of ash in coke at start.....		1.5127
Grams of ash in unburned coke.....	0.6351	
Grams of ash actually burned part.....	0.8764	1.5115
Unaccounted for.....		0.0012

Sulphur Balance

Grams sulphur in coke at start.....		0.1844
Grams sulphur in unburned coke.....	0.0506	
Grams sulphur in ash.....	0.0013	0.0519
Grams sulphur gone off in gas (by diff.).....		0.1325

0.1338 gram (0.1844—0.0506) of sulphur left the coke.

Of this 99.03 per cent went off in gas while only 0.97 per cent remained in the ash.

Another Test

Another sample of coke was obtained containing ash, 6.96 per cent, and sulphur, 0.759 per cent. Several pieces of this coke were placed on a fireclay cylinder standing upright. The coke rested on a screen, being heated by a blast lamp burning full blast for 1½ hours. The results obtained were similar to those in the first test, although in this case some of the ash was disturbed in the coke by the blast. The unburned coke contained 9.12 per cent ash and 0.686 per cent sulphur. The ash from the burned coke contained 0.135 per cent sulphur. Several other pieces of the coke were heated in the cylinder by a blast lamp for 2¼ hours and in this case the unburned coke contained ash, 9.72 per cent and sulphur, 0.657 per cent. This shows a still greater increase in the ash and a corresponding decrease in the sulphur.

From these tests it is apparent that when coke is only partially burned, the unburned portion is higher in ash and lower in sulphur than the original coke. The ash will not fall off while the coke burns if undisturbed. Only 1 per cent of the sulphur in the coke remains in the ash, the rest passing off in gas. Whether any of this sulphur is absorbed by the iron and if so, what amount, can best be determined by work on a cupola in actual operation. However, if iron melted in a cupola increased in sulphur, it certainly must have taken it up from the coke, the limestone or from some other part of the charge.

The samples of coke received from the Michigan Stove Co. analyzed as follows:

Fresh coke—Moisture, 0.12 per cent; volatile matter, 0.77 per cent; fixed carbon, 91.43 per cent; ash, 7.68 per cent, and sulphur, 0.582 per cent.

Burned coke—Moisture, 0.15 per cent; fixed carbon, 91.07 per cent; ash, 8.78 per cent, and sulphur, 0.527 per cent.

Limestone nearly always contains some sulphur and this may have considerable bearing on the iron. The chemist ventured the opinion that it does so because much of the sulphur of the coke passes off in the gas in the form of sulphuric acid (SO_2), while the sulphur in the limestone present at CaSO, would probably be partly at any rate, if not entirely, reduced to CaS, which being non-volatile, would tend to come in contact with the molten iron and give up its sulphur to it.

Report of the Committe on Industrial Education

PAUL KREUZPOINTNER, *Chairman*

During the past year progress has been made in the introduction of industrial education though by no means as fast as is desirable in the interest of the country and the industries. We have not yet come down sufficiently to "hard pan" to make the people see that the mental resources of our country need developing even more than do the material resources, important as the latter are. Efficient industrial education costs money and the taxpayers are slow to make the investment as, after all, money expended that way would prove a valuable investment. In numerous cities investigations are being made to ascertain what is needed along lines of industrial education and to what extent the resources of the respective cities can lend their help.

Only six states have thus far inaugurated definite systems for the organization and supervision of industrial schools. These states are, Pennsylvania, Wisconsin, Indiana, Massachusetts, New York and New Jersey. The most decided progress has been made by the establishment of corporation schools the number of which is growing rapidly, this country having already as many students in corporation schools as there are in German corporation schools. These schools are becoming a most valuable help to the industries as well as to the communities and because of their growing importance to the cause of industrial education your chairman presents to you, in the form of an annual report, an address on; "The Relation of the Public School System to Corporation Schools", which he had the honor to deliver at the Second Annual Meeting of the National Association of Corporation Schools, held at Philadelphia, Pa., June 9-12.

As the members of the American Foundrymen's Association will notice, the subject matter of the address is so inti-

mately related to the progress of industrial education in this country that it deserves the earnest attention of every member.

During the past year your chairman attended the annual convention of the National Society for the Promotion of Industrial Education; the National Society for Vocational Guidance; the Pennsylvania State Education Association; the annual meeting of the Department of Superintendents of the National Education Association, and of the National Association of Corporation Schools. Your chairman also had the honor to attend the Fifth National Conservation Congress at Washington, D. C., November 18-20, as the official representative of the American Foundrymen's Association. Under a separate report your chairman takes pleasure to present the principal points of the proceedings of this memorable Congress, believing to have faithfully recorded the opinions and wishes of the members of your Association.

Your chairman also visited, in the interest of industrial education, the school systems of Winnipeg, Can.; Gary, Ind.; Grand Rapids, Mich., and Richmond, Va. At Winnipeg and Gary your chairman was accorded the privilege of addressing teachers' associations. At Grand Rapids he had the pleasure of addressing the board of education and at Richmond visits to schools, industries, Y. M. C. A's, Mechanics Institute and a study of Virginia's resources at the State House made your chairman take the liberty to call the attention of the authorities to the need of additional branches of industrial education, the discussion on the subject being gratefully received. During the year your chairman was honored by the Deputy Minister of Labor of Canada with a copy of the report of the Royal Commission on Technical Education and Industrial Training. The report is contained in four volumes of 2,250 pages dealing with school conditions of the whole of Canada, of industrial schools in the United States, England, Scotland, Germany, France, Switzerland, Belgium and Austria with a summary of the findings of the Royal Commission. The report is a most exhaustive, thorough, frank and conscientious presentation of actual conditions and is to serve as a basis for the establishment of a system of technical and

industrial schools in Canada. In thanking the Deputy Minister of Labor of Canada, the Honorable F. A. Acland, your chairman made some comments upon the subject matter of the report by the Royal Commission on Technical Education and Industrial Training which were received with the assurance of being valuable suggestions for the attention of the Royal Commission. I thank you for the confidence accorded during the year to your Committee on Industrial Education.

Corporation Schools

Corporation schools are nothing but specialized continuation schools. The fact of the corporation school being under private management does not alter the relation of the subject matter taught in the public school to the subject matter taught in the corporation school and therefore the corporation school may in justice ask of the public school equally efficient preparation for the pupils, destined for vocational life, as the public school furnishes to the pupils entering professional life. The more so because the corporation school relieves the public school system of the expense of establishing industrial schools to do the work done by the corporation schools.

If this were not done the efficiency of industries would be impaired which, in turn, reacts injuriously upon the community, just the same as the community will suffer in other directions if there is insufficient preparation of its citizens and workers. No matter by what agency the work of the public school system is continued, the effects upon the mental, moral and material standard are always the same.

Function of the Corporation School

The object of the corporation school being to increase the efficiency of the industry which the school is going to serve, the function of such a school is:

First:—Developing and broadening whatever talents and training the pupils bring with them in order to increase the efficiency of the plant as well as of the employe himself.

Second:—To study the talents and characteristics of the apprentices in order to draw conclusions as to their availability for particular kinds of work and their suitability for advancement.

Third:—To create such favorable mutual relations between employer and employe as will tend to minimize antagonism between capital and labor and create a spirit of co-operation.

To the degree that these functions are realized, to that degree corporation schools will benefit the industries and at the same time react favorably upon the ethical and economic life of the community by raising the intellectual and educational standard. However, the extent of these benefits depends largely upon the preparation with which the public school system is going to equip the young people. It is the kind and degree of this pre-vocational training which will determine the ability of the apprentice to make the best use of his faculties and to be prepared for the intelligent exercise of his rights and duties as a mechanic and citizen. As a consequence the success of the corporation school will depend largely upon the pre-vocational training and the aggregate results of the corporation schools will, in no small degree determine the ability of our industries to retain their present commanding standing and to adjust themselves to ever tightening economic conditions and to meet home and foreign competition.

The mental, moral and material standard of the social structure can only be maintained by the constant and unhindered action and reaction upon each other of all social and educational forces. Hence the intimate relation of the public school system to the work and aims of the corporation school. Several national factors have contributed to the industrial success of Germany and not the least of these factors has been its educational system and continuation schools, the latter of which were organized in Bavaria in 1803 and in other German states soon after. They prevent educational waste and, in their present form, have become the strongest tie between the schools and the industries. They are the surest

proof of the close relation of the public school system and the corporation schools.

Indeed, every concession for a corporation school by the government carries with it the obligation that the minimum standard efficiency for the corporation school is equal to the standard of the public continuation school. They may go beyond that standard to any extent, and the elementary schools must contribute their share to this success. The unity of purpose and harmony of action shown by the people to tax themselves for these schools is remarkable if we consider that wages are but about two or three fifths of what they are with us. At Munich the cost per pupil is $27, in the elementary schools, $23.30 per pupil in the continuation schools for boys and $18 for girls. Thus, the closest relation between the public school and vocational life, and incidentally the corporation school is attained. In Germany 50 per cent of the corporation schools deal with apprentices exclusively, with 33 per cent the pupils are nearly all unskilled workers, and in 17 per cent of the schools both classes are taught.

In order to ascertain what kind of a preparation might reasonably be expected from the public school system for the pupils of the corporation school let us see what these schools are teaching. On account of the great diversity of local and industrial requirements the subjects taught include drawing, algebra, mathematics, mechanics, physics, chemistry, metallurgy, language, composition, geometry, materials, economics, industrial history, elementary review of processes for the conversion of raw materials into useful articles, trade history, etc. These studies, while directly applicable to trade training also tend to arouse in the industrial worker an intelligent perception of the influence of his work upon his own and the prosperity of the industry he is engaged in and of the relation his work bears towards the advancement of the community of which he is a citizen. Hence the desirability to sprinkle civics and economics through the course of instruction especially where semi-skilled and unskilled are included in the school.

The Public School System

The public school system is just now in the midst of a period of readjustment to meet modern industrial requirements

and therefore is not in a position to respond readily to the necessities of the corporation schools. The old order of the public school to prepare for higher education still prevails in our educational system and that most important link between the elementary school and vocational life and the corporation school, namely the continuation-part-time and industrial day school is only in the experimental stage here and there. Fortunately the school men have made considerable effort lately to devise a program of readjustment and if the National Association of Corporation Schools will endorse the two reports of the committees of the Council of Education of the National Education Association: "Economy of Time in Education" and "The Reorganization of Secondary Education", and assist locally to have the subject matter of these two reports adopted by the school authorities, then an important step forward in the readjustment of our schools would be taken for the needed preparation for corporation school pupils, provided the gap from 14 to 16 is filled by an effective system of continuation schools.

What kind of preparation may we expect from the public schools and the continuation schools? What is the attitude of the school men towards the industries and industrial education? There is a growing tendency to infuse work of an industrial nature into the public school curriculum. The curriculum of the Horace Mann School of New York is an example. Beginning with the first grade industrial subjects are introduced as for instance in the first grade clay, its source, uses and main characteristics. Processes involved in making things of clay, as shaping, drying, firing and glazing. Paper, textiles and wood are similarly treated. In the second grade plant life is studied; in the third grade garden work is introduced. In the fourth grade agriculture, fishery, mining and quarrying. In the fifth grade trees and forestry are the subjects studied. In the sixth grade general science is entered into with a study of the water supply of New York. What makes an engine go? The balloon and airship are also considered. And so additions are made from grade to grade, including divers and submarines, electric lamps and electric heating apparatus. What

are earthquakes? Why is fresh air so necessary to our health? Our eye and ears. Arithmetic, history and geography are correlated to the work.

In its report on "Vocational Training" the committee of the City Club of Chicago recommends a two year elementary vocational course for the seventh and eighth grades, including building trades, machine trades, furniture trades, printing trades and general woodwork for boys. Bookbinding, photographing, engraving, dress making, millinery, garment making, embroidery, laundry, cooking, institutional and lunch room management for girls, specialization not to be permitted. In the Farragut school in Chicago an industrial course was introduced in the sixth, seventh and eight grades, allowing 615 minutes per week with 270 minutes for academic subjects. At Menominee, Wisconsin, trade instruction is offered in a few classes, instead of the regular manual training, in the sixth, seventh and eighth grades. In Cleveland, an elementary industrial school was opened from the sixth to the eighth grade, giving woodwork, printing, drawing, practical mathematics, English, spelling, geography, history, reading, hygiene and general exercises. In two public elementary schools in Boston ten hours a week are given to an optional course in wood and metal work.

The most radical departure from the traditional public school is found at Gary, Indiana. Industrial and academic subjects are closely correlated and the whole course, up to the twelfth grade, there being no regular high school, includes industrial subjects. The teachers for the industrial subjects are expert mechanics, while regular teachers take up the academic subjects. Besides these and similar efforts to begin preparation for vocational life in the elementary schools there is an increasing tendency to broaden the regular curriculum by the infusion of social, economic and civic subjects. Thus, at Johnstown, Pa., the following has been added: First, second and third grades, sources of food, shelter and clothing for the inhabitants of Johnstown. Historic Johnstown is taught in the third grade. In the fourth grade, lumbering and milling, coal mining, quarrying, manufacture of coke and fire

clay; in the fifth grade, fire and police departments, educational institutions, churches, hospitals, lyceum, philanthropic associations, public buildings; in the sixth grade, transportation as railroads, street cars, automobiles, drays, streets, their care, paving, sidewalks, water supply, sewers, public health, the park system; in the seventh grade, manufacturing, an intense study of the steel industry; also other manufacturing; and in the eighth grade, the city government, executive, legislative, judicial, gas and electric lighting, telephone and telegraph are covered.

In Cincinnati the teachers have been asked to answer the following questions:

Civics:—What topics have your pupils discussed? Have citizens addressed the pupils on civic topics? With what other subjects do you correlate that work? What civic excursion have any of your pupils taken? If you have done any work that is distinctive describe it? What suggestions can you make for the improvement of the work in civics in the grade schools?

Vocational Guidance:—What vocational subjects has your class studied? Which subjects have you studied systematically by a carefully prepared lesson plan? Which subjects has your class studied through reports from the children on vocations in which they are particularly interested? What has been your class room method of the treatment of vocational subjects? Has your class visited any industrial plants in connection with vocational studies? To what extent have you been able to correlate the vocational topics with civics? How and to what extent have you gained the co-operation of parents in this work? How much time per week do you give to the civics and vocational topics combined? What do you regard as the most valuable phase of the work? What suggestions can you offer for the future development of the work?

All such infusions and additions to the regular school work are a valuable source of preparation for specific trade training since it accelerates the development of general intelligence.

It is not the acquisition of manual skill in the elementary school which is most helpful in preparing for vocational life but the systematic combination of object lessons with the aca-

demic subjects leading to a comprehensive understanding of vocational and civic activity, with the manual work merely serving as an expression of the inclination of the pupils and not as a preparation for a particular industry. The continuation school is to pick up the thread where the elementary school left off.

Continuation Schools

No amount of readjustment of the elementary school in favor of those who are to enter vocational life will be of any particular benefit either to the pupils, to the industries, or to the communities unless such work is followed up by an effective system of continuation schools, either all day schools, or, when the pupils are already at work, following the plan of the Wisconsin schools, or the Cincinnati continuation schools for metal trades. It does not matter what they are called or what form they are given, if they only fill the gap between 14 and 16 or 18 years of age, as circumstances may require in order to prevent the enormous educational waste now occasioned by the young people forgetting what little they have learned in the elementary school and then a very few of the brightest and strongest trying a few years later to make up the loss in makeshift evening schools. I found this loss forty years ago with the boys of the "Free Evening Industrial School" which I started at Erie, Pa. in 1874 and it was found, when at the beginning of this year, the United States Government organized continuation schools among the 50,000 navy men. For this very reason and in order to preserve for the vocational requirements of the boys, the acquirements of the elementary schools, continuation schools were organized in Germany.

And nothing less than a rigidly compulsory system of continuation schools, compulsory for the parent, employer and employe, will prevent this enormous educational waste in our country and at the same time prepare for prospective specialized trade training, or for semi-skilled or unskilled occupations. This educational waste is even greater with us, with more deteriorating financial, intellectual, moral and social consequences because, while in European countries vocational life begins at 14, we have nothing to fill the gap from 14 to 16. Thus we waste the most valuable asset our country possesses,

the mental resources of millions of prospective industrial male and female workers and future citizens.

And these continuation schools must train for community life as well as for industrial life. Both are interdependent in their reactions upon each other. A vocational training which continually appeals to the egotism of the person, appeals to nothing else but to increase one's earning capacity and how to get on top of the other fellow, will, in the long run, react injuriously upon itself. As a matter of course all such vocational elementary and continuation school education should be organized by leaving the top open for the talented ones to escape above.

This calls our attention to a phase of present vocational education in laying too much stress upon purely manual training. Our pioneer life and national development has tended to emphasize the development of mechanical ingenuity and handicraft skill. If then, in our system of industrial training we over-emphasize the training of those habits and inclinations, like inventive expression and manual dexterity, which are already a second nature with the people and pay too much attention to these, already alive faculties, the development of other dormant, and more valuable faculties is hindered and neglected and their value is lost to the pupil, to the industries and to the community.

This educational waste through arrested mental development is aggravated by atrophying influences upon the mind through unavoidable monotony of occupation by specialization, and thus we are liable, through misdirected education, to train a nation of automatons with all that implies with the present tendency toward universal democracy.

Continuation School Course

A progressive continuation school course, flexible enough to suit local conditions, might include freehand and mechanical drawing, arithmetic, geometry, algebra, correlated to the mechanical work. Industrial history, geography and location of raw materials used in the industries might also be correlated. A knowledge of the qualities of metals and other materials

and the processes, explained in a simple way, by which they are produced from their raw materials is very essential nowadays. Estimates of cost of the work done by the pupils, simple bookkeeping with an elementary explanation of business rules and of drafts and checks should be included. Languages, correct writing and composition can be correlated and should include personal correspondence with parents and friends about the pupils' position, his likes or dislikes for his work and surroundings, how he spends his leisure time, what amusement he prefers, etc. Business correspondence might include letters of application for position, apprenticeship contract, work certificate, principal points of efficiency required in the industry, in public life, ordering and receipting for goods, complaints about delayed or damaged goods, accident and life insurance, fire insurance, notes and drafts, etc. The culture, industries and commerce of the countries with which the United States is in competition, economics and conservation of resources can be correlated also. History of inventions, transportation facilities of the country, elementary experiments and demonstration of the properties and qualities of bodies, motion, atmosphere, heat, light and electricity, the rights, duties and responsibilities of citizenship and good reading should be encouraged in order to arouse a desire for wholesome literature, moral and patriotic sentiments. Pupils of 17 or 18 in the continuation school, part time, or industrial day school, or corporation school, are sufficiently advanced mentally to grasp such topics as competing countries according to their importance in resources, productivity, industries, commerce, transportation and institutions and elementary points in law as they affect the life of the industrial worker and citizen. Economics in time, material, resources and preservation of health play an increasingly important part in the household of industrial nations, hence should form part of the young workers' instruction so as to enable him to draw rational conclusions from the social-economic happenings around him and to give him the reasoning power to inquire into the whys and wherefores of measures which affect him economically. The formation of excursion clubs, athletic clubs or reading clubs could be made

the vehicle to impress them with the value of sensible rest and recreation. Such topics might be debated or discussed informally as the production of goods and values, factors of production; resources; capital and labor; what makes labor effective; nature and function of capital; co-operative factors of production; economic conditions underlying industrial society; nature and conditions favoring transportation in different parts of the country and their influence in developing industry and agriculture in different sections; system of weights and measures; principles underlying credit; income; wages; profits; strikes; investment; consumption; economic and uneconomic consumption; competition, at home and with foreign countries. There would also be an extension of the subjects of physics, chemistry, mechanics and materials.

Attitude of the School Men

No ever so elaborate consideration of the relation of the public school system to corporation schools will give effectiveness to this relation and produce practical results unless the confidence and co-operation of the school men can be secured. The so-called "dual" system of industrial education, with its proposed separation from the public school system under separate laws, finances and management would deprive industrial education of this confidence and co-operation to a large extent, compel the industrial school to do preparatory work which ought to be done in the elementary school, thus losing the opportunity to do advanced work at a period of mental development when the pupils are most receptive. Upon the other hand it would take away the incentive from the elementary schools to do better work. With the introduction of compulsory continuation schools in Cincinnati for those who had gone to work at 14 without an eighth grade education, weak points in the grammar course revealed themselves and the grammar teachers at once set to work to strengthen these weak points. Thus the close relation of both schools produced a healthy reaction and sympathetic response. The "dual" system would prevent this sympathetic reaction and avoidable educational waste would result.

The attitude of the schoolmen towards the industries and their representatives is now one of suspicion due to the inconsiderate haste with which some well meaning people demanded trade education from the school people and then abused them and made the school people responsible for conditions which were beyond their power to remedy. Again many men elected as members of school boards, smart business men, good financiers and organizers in their own sphere, considered themselves infallible in dealing with school matters, lost patience and assuming a dictatorial attitude forced measures down the throats of superintendents which hindered instead of helping progress and thus the school men, naturally conservative, came to the conclusion, rightly or wrongly, that the industrial people were going to commercialize the public school system. Hence the attitude of suspicion. Now this attitude could be quite easily overcome and the co-operation of the school men be secured without difficulty if allowance is made for the nature of the obstacles that lie in the path of such speedy readjustment as seems to be desirable from the industrial standpoint.

The complexity of our educational system, the lack of concentrated power to force needed changes, or if forced to carry them into practice and make them stay, the everlasting changes in the personnel of school boards with their often ignorant members, the insidious corrupting social, political or commercial influences, the indifference of the people and the reluctance to furnish funds to meet the increasing demands for efficiency of the schools, the insufficient training of teachers and their frequent renewal, the still powerful domination of the universities and colleges upon the schools below, all these conflicting forces and cross purposes being constantly at work make it very difficult, even for the progressive schoolman, to do as much as he would like to do. Frequently his conservatism is forced upon him. Considering the many adverse circumstances they had to overcome the school men deserve credit for what they have accomplished for the promotion of industrial education and if the National Association of Corporation Schools will lend a helping hand in removing obstacles

there will be hearty good will, mutual confidence and co-operation in a short while.

The report on "The Reorganization of Secondary Education" and "Economy of Time in Education", are so timely and sane in their conclusions and so suggestive for the purpose of laying a good foundation for industrial education purposes that the endorsement of these two reports by your Association would furnish the basis for harmonious relations with the school men by enabling both the industries and the school to stand upon common educational ground, each party receiving a large share of valuable assistance. If the industrial people would urge upon their local school authorities the adoption of these two reports as a guide for action much would be gained.

Conclusion

This brief review indicates the close relation of the public school system to corporation schools; it indicates that they should not be separated but while each is pursuing its own way, they should co-operate with each other in order to prevent educational waste and to promote an active reaction; and last but not least, although neither the elementary school, nor even the continuation school can be made, nor ought to be made so exclusively industrial as may seem to be desirable from a superficial survey of conditions, because of the social necessity of these schools serving the community interest first, nevertheless, the preparation the public and continuation school is able to give and is going to give under the guidance of the awakened progressive spirit of the school men with the intelligent co-operation of the industrial men, will be found sufficient and efficient for the needs of the corporation schools. What preparation is needed is not so much specific technical knowledge or mechanical skill, of a sort that cannot be readily applied, but what is needed is a serviceable stock of fundamentals, a receptive mind and a willing attitude on the part of the pupils.

Discussion of Industrial Education

MR. PAUL KREUZPOINTER:—Mr. President and Gentlemen: The report of the chairman of your committee on industrial education treats of a subject this year which is bound to play an important part in relation to our industries in the future, and this is corporation schools. We have already as many corporation schools and pupils in these schools as they have in Germany, and their number is growing. Your chairman would ask you to read the report with care, because with the breaking out of the European war we are entering upon a new stage of our industrial development. Not only is there a demand that we supply the markets which are supposed to be lost to the belligerent nations, but after the war these nations will be obliged to strain every nerve to build up their industries and being under straitened circumstances will be more formidable competitors than before. Thus, we will be compelled to increase our efforts for the development of the mental resources of our country. We cannot conquer foreign markets without developing those mental qualities and faculties which have enabled our competitors to conquer and hold these markets. Some people seem to think all we have to do to conquer, say the South American markets, is to hire ships to send goods down there and then go down and sell them.

Now in the first place, the South Americans are not waiting for us to buy our goods. In the second place, banks alone do not create and hold foreign markets; all those who are engaged in the transaction, down to the clerk and mechanic producing the goods have to be educated up to the exporting business. They will not buy what our drummers think they ought to take; they will buy what suits them, not us. We have neglected to train our commercial people in foreign languages. A movement is now on foot to teach Spanish in our high schools. This is very good, but where are the teachers to teach Spanish? I know one high school

where Spanish will be taught this coming term. That teacher also teaches French and German. How much serviceable Spanish do you think these pupils will get in that high school? Such kindergarten work will not conquer foreign markets.

What is wanted are teachers of foreign languages, who, while teaching the language are able to correlate with their teaching something of the character, customs, habits, usages, resources, exchange and methods of doing business in foreign countries. I know a case where an American furniture firm sent an agent to Mexico to sell furniture. The agent could not speak Spanish but had to hire an interpreter; he also knew little or nothing of their money and manner of doing business. He stayed a week in a certain town and sold nothing. While he was there a German furniture man came in and within a week sold $10,000 worth of goods. Why? He could speak Spanish, he knew the money, he knew and adjusted his dealings to the character and habits of the people, he did not tell them that this is the thing they like in the United States or in Germany; but he tried to find out what they wanted and what pleased them, not him.

Now then, gentlemen, if you wish to do something toward conquering South American or other foreign markets go home and bring pressure to bear upon your high schools, elementary schools and industrial schools not only to teach foreign languages but to teach all of those technical, economic and social subjects which are necessary to raise the general intelligence and skill of all the people engaged in commerce and industry as high as did those nations who conquered those markets in the first place. When our young people leave the academic or technical high school they know practically nothing about the history, life, resources, transportation, laws, climate, industries, etc., of other countries except perhaps a little of England.

This clamor for foreign markets will also be useless unless we develop our industrial schools more intensely along technical and economic lines so that our materials and time are used more judiciously and less wastefully. If our competi-

tors have the skill, knowledge, civic sense and responsibility to use inferior raw materials to better advantage than we do and know how to use their time more economically, then we will have to do the same or else we stay behind.

If Germany has been able to forge ahead industrially it is not due alone to her educational system; other causes have helped but much of her success is due undoubtedly to her system of industrial training of the masses of her industrial workers, skilled, semi-skilled and unskilled. And this training does not lay emphasis so much on manual dexterity as on instruction in technical knowledge, science, economics and the development of a sense of civic duty and a comprehension of one's rights and responsibilities. In other words, they blend the mechanical with the cultural, the commercial aspect of life with the ethical aspect of life. In England likewise, they are coming to similar conclusions.

Now, gentlemen, these are the forces we have to deal with. Whatever gain may come to our commerce and industry eventually as a consequence of this European war will have to come through increased mental and physical ability and the development of the talents which now are lying dormant in our young people.

Training For Foundry Leaders at Wentworth Institute

By E. A. Johnson, Boston.

The progress, growth and ultimate development of the foundry industry must depend in the long run, as in every industry, upon two principal factors. *First,* the intelligence, ability and the supply of the rank and file workers, upon this broad foundation every industry must rest. *Second,* parallel with this and of equal importance, for the future success of the foundry industry, is the ability, leadership, foresight and wisdom of those who are controlling, managing and directing American foundries and foundry operations in all of their departments.

Two years ago I presented to the Association a paper describing what Wentworth Institute was then aiming to do in training a superior type of workmen to fill the universally felt want along the first of these requirements that I have described. Today I desire to bring to your attention a new development of our work which is directed toward the training of leaders to supply the equally important need that I have just outlined as the second essential factor in American foundry progress.

The Requirements for the Progressive Leader In the Modern Foundry

The leader in the modern foundry has a great variety of responsibilities. His position is a complex one. It includes getting business, managing men, the upkeep of complicated mechanical equipment, the developing of better methods of foundry practice, the improvement of quality of product and the decreasing of costs. All of these things are important and it is worth while for us to stop to consider what kinds of ability he must have in order to succeed in each.

He should have mechanical skill and ability to use his own hands in all the different kinds of work that come within the

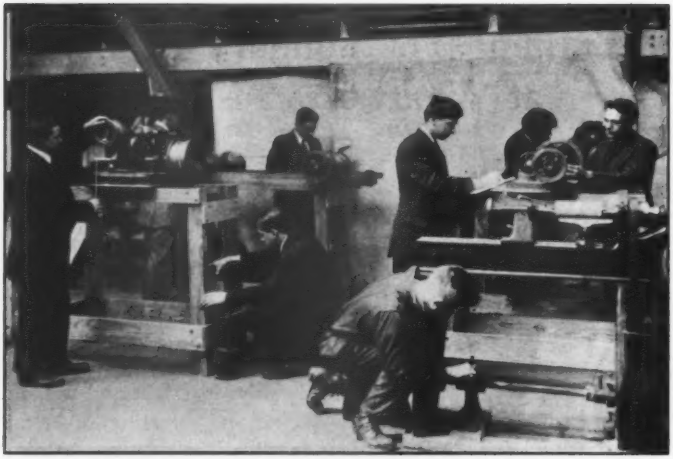

FIG. 1—A FEW PRACTICAL PROBLEMS IN GEARING

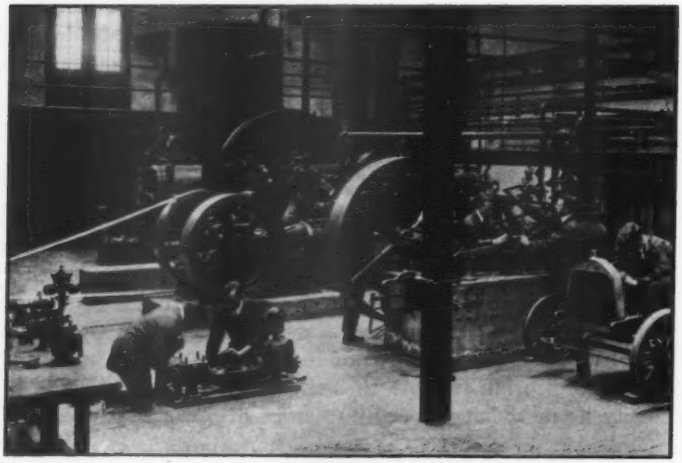

FIG. 2—TEACHING THE PRINCIPLES OF STEAM ENGINEERING

FIG. 3—TEACHING THE PRINCIPLES OF ELECTRICAL ENGINEERING

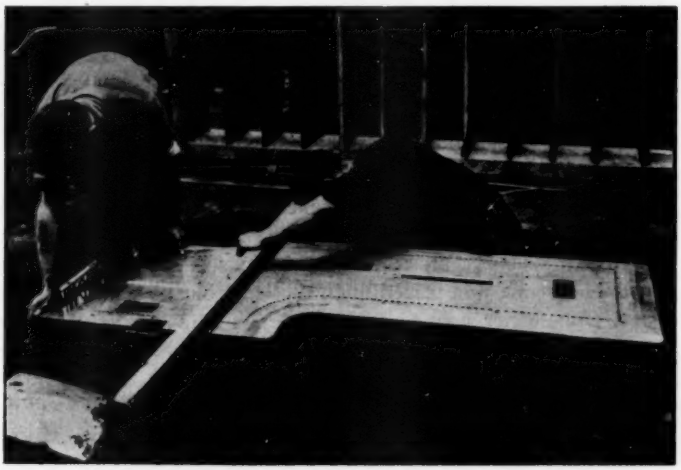

FIG. 4—FIRST STEPS IN AN INTERESTING PIECE OF DRY SAND WORK

line of business that his foundry is now doing, or, in its natural growth and extension, may do. He must be able to judge what is a fair day's job, and in reality he has to be a teacher who can develop the men to do better than they have been doing and better than they are doing in his competitors' shops. If he has not the comprehension of the elements of mechanical skill that enter into each job, his competitors are going to have the advantage over him along this line.

FIG. 5—PUTTING THE FINISHING TOUCHES ON A MOLD

For example: I recall an instance where a railroad had been having constant trouble in getting castings of the quality that it required. The eccentrics and eccentric straps especially gave trouble. Blame was placed upon the iron, but no one knew the exact trouble nor how to correct it. As a matter of fact, the iron was of good quality and the molding was all right with one exception, the gating was the cause of the entire trouble. The manager of the foundry was an excellent business man but his foundry lost those particular castings and also the entire business of the railroad because he did not know a simple mechanical detail of an ordinary job of molding. Illustration

after illustration might be cited to show the advantage of ability to do one's self the things that one must direct others how to do.

The foundry leader, too, must have certain kinds of technical knowledge of the kind which will enable him to organize the work in the shop; ability to judge what jobs may be made into machine jobs with profit, what kinds of machines to use in each case and how best to mount the patterns; the size and

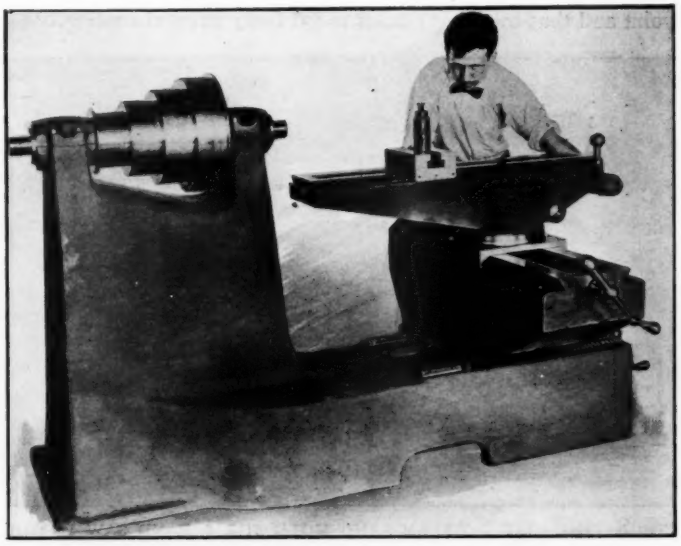

FIG. 6—CASTINGS MADE AT WENTWORTH INSTITUTE

shape of the flask to be used; the depth of copes and drags required, the method of gating, etc., in order to get the maximum production in the shortest possible time and with the least possible losses through misrun castings and other causes.

He must also have ability to plan match-plates and matchwork of the various kinds to be used in connection with molding machines; or otherwise, to effect saving in time and increased output. And in a thousand and one other ways he

must have accurate, detailed, technical knowledge in each branch of his business.

To illustrate: The driving gear on a heavy duty printing press is an important casting. There is danger of spongy weak metal at the base of the teeth near the point where the arms join the rim. One of the largest jobbing shops in the middle west lost a very considerable amount of excellent gear blank business simply because the manager did not know the importance of reducing the size of the fillets on the patterns at this point and thus avoiding porous metal from unequal cooling.

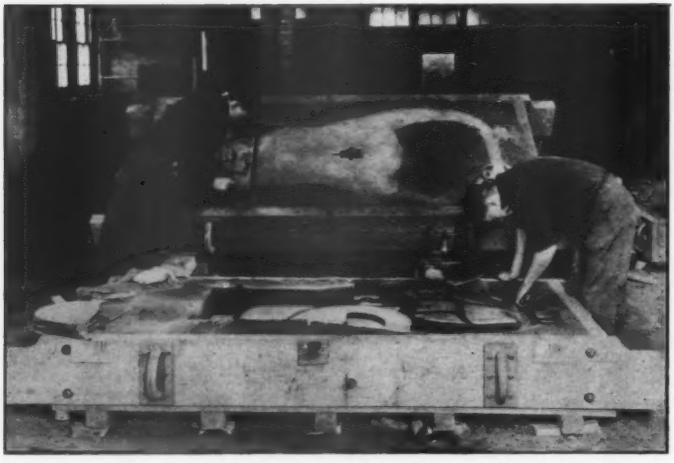

FIG. 7—FINISHING A GREEN SAND MOLD FOR A BAND SAW FRAME

In producing heavy castings the leader in the modern foundry should know how to determine rapidly and accurately the amount of metal to run different kinds of castings; the proper pouring temperature of the metal which will produce the best results for every grade; the kinds and qualities of sand best suited for each variety of work; and the proper facings to be used. He must also understand the cupola in all its functions. He must be thoroughly familiar with up-to-date methods of mixing, of charging, and of melting; and he must know the effects on the metal when the conditions of melting are varied.

He must know the relations of pressure and volume of blast, of depth of bed, height of melting zone, tuyere openings and time, —all as applied to the melting of metal in the cupola.

To cite one more illustration: This time an experience of where a little bit of technical knowledge of mixtures and judgement in cupola practice was worth thousands of dollars:

One of the best drop forge men in the United States was having trouble with the dies that he used for forging heavy front axles of automobiles. The machining of these dies cost $700. It was an extra heavy job and the regular grade of cast-

FIG. 8—A STUDY IN COMPARATIVE EFFICIENCY AND COST

ings that he had been getting stood up for only two dozen axle forgings. At this rate the axle forgings were expensive indeed. A foundry competing with the one that was regularly furnishing these die blocks was told of the trouble and was given the privilege of furnishing a trial set of blocks. By making a special mixture, planned to be low in graphitic carbon and therefore low in silicon but high in manganese, a different result was obtained. Great care, too, was used to keep both the sulphur and phosphorus low. The charge was planned so as to get an extraordinarily high temperature; and as a final precaution, in

order to insure the best possible result, about ten per cent of vanadium steel clippings were added to the charge. The steel clippings cost less than ordinary cast iron scrap, but the result of that set of die-blocks enabled the competing foundry—through just a little accurate technical knowledge—to build up an enviable business and reputation in die-block work. At the same time it received 75 per cent above the market rate for all this class of its product.

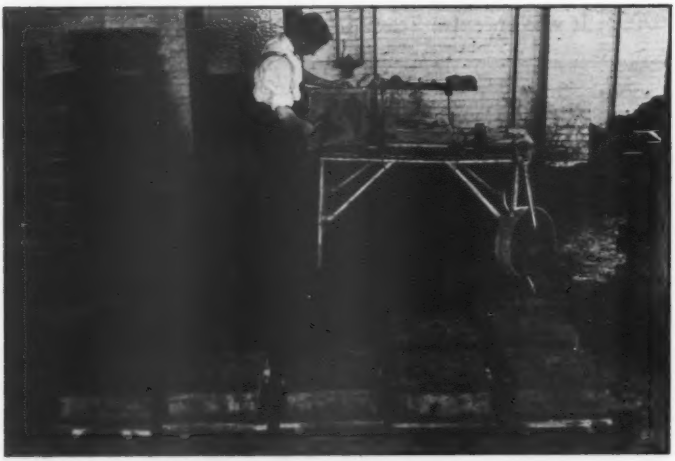

FIG. 9—COMPARING ORDINARY BENCH MOLDING WITH MACHINE MOLDING

It is not necessary for everyone in the foundry industry to have this kind of technical knowledge but somewhere in every plant there should be a leader, at least one, who has mastered these technical details and who can solve such problems as those involved in the example that I have just described.

Our leader, too, has got to have an engineering appreciation of the generation of steam, power transmission, applied electricity, compressed air, ventilation, etc., subjects covering pretty nearly the whole field of what is now regarded as the profession of engineering, for now-a-days foundry equipment touches all of these fields.

He must also have a sufficient mastery of the pattern maker's art to enable him to determine when savings may be effected by altered patterns that will simplify molding. To illustrate: I remember a pattern from which hundreds of castings had been made in one shop. The work was transferred to another foundry because the castings were not up to the required standards, and deliveries were not prompt.

These castings were in the shape of a ring about 4 feet in diameter with a heavy flange to which steel plates were to be riveted. The whole trouble was with the cored rivet holes

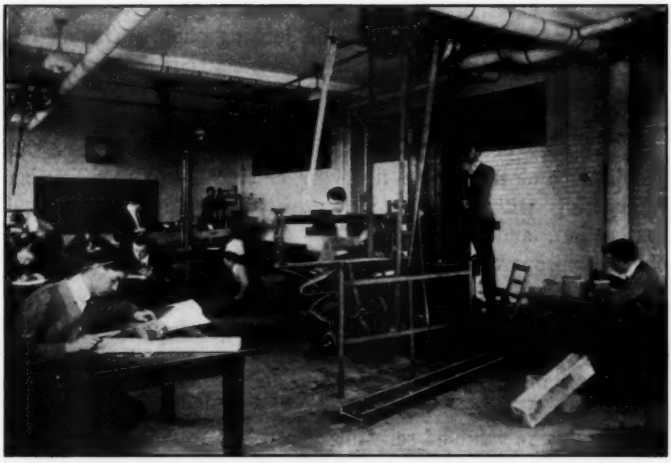

FIG. 10—TESTING THE PHYSICAL PROPERTIES OF ALL KINDS OF MATERIAL

through the circular flange. The pattern had 96 separate stop-off prints placed on the inside face of the pattern, leaving 96 narrow necks of sand between them. The setting of these particular cores always resulted in some crushing, and always required patching, which consumed time, and resulted in rough surfaces on the casting where smooth work was required, and also caused a high percentage of loss.

These castings weighed about 400 pounds and one casting made in this way was considered a day's work for a molder and a helper.

When the pattern arrived in the new shop it was altered by placing a continuous flat print over the whole inside face of the ring. For the 96 cores six new cores were substituted each having the proper number of projections. These larger cores required only a few moments to set. The castings came out with the desired smooth surface and the work was so simplified that failures were almost entirely eliminated. One molder and a helper with the altered pattern now made three castings per day.

Problems of this sort are met with constantly in practise. Each one of you knows from his own experience dozens of similar examples, especially in the jobbing shop. The man in charge should always be ready to devise changes that will effect economy not only for his own plant but also for his customers' plants.

The core room and cleaning department each offers its problems, and the whole fields of chemical and metallurgical engineering with their problems of temperature, heat value, combustion, and the relationships between the chemical and physical properties in the foundry materials and foundry products are also matters that must come within the accurate appreciation of the modern foundry leader.

Speaking generally, manufacturers everywhere appreciate the importance of all the things that I have outlined and recognize the advantage to be derived from their adoption. They understand the value of scientific control of foundry operation.

And yet, while this is true, there is still a large percentage of foundries where old methods of operation are still in use. This fact cannot be questioned. Foundrymen everywhere are familiar with the reason. They are forced to continue operation in the old way simply because of their inability to get men with the training and with the leadership required to carry on the work in accordance with the best accepted standards of the trade.

It is not necessary to argue the point. It is self-evident that the apprenticeship system, as it has been carried on in foundries, does not produce men who have the proper training to succeed in managing a plant in accordance with the modern ideas that

FIG. 11—SPECIAL EQUIPMENT FOR DETERMINING THE PERMEABILITY OF MOLDING AND CORE SAND

we all are prepared to accept. It is also self-evident that practical experience alone is no longer sufficient. The "rule-of-thumb" methods will not solve the kind of problems that I have tried to suggest.

New Course at Wentworth Institute.

Wentworth Institute, realizing this situation, has determined to offer a new two-year course designed to train men to fill this need, who will be capable of grappling with just the sort of problems that I have tried to outline. The vital importance to the foundry industry of a sufficient supply of such men is so great that I feel sure that a brief description of the course will prove of interest.

This new course is intended to train young men exclusively for the advanced positions in the foundry industry, for those positions which require a combination of skill, intelligence and technical knowledge. It is planned to give both a broader practical training and a more thorough comprehension of the scientific principles that underlie modern foundry practice than can be obtained through practical experience in commercial shops today.

The work of the new course, which we call Foundry Management and Operation, is divided into seven general headings.

First. Shop experience: Three-eighths of the entire time during both of the two years is given to gaining experience of this kind in bench and floor molding for iron, brass and other alloys, and in machine molding, coremaking, finishing, and in cupola management. The plan is to include all the common types of work that are met with in the best modern foundries. By carefully economizing the men's time and by seeing that there is no wasted effort through repetition and doing unnecessary kinds of work from which little benefit would be derived, it is confidently believed that in two years more practical skill and experience can be given than young men would get in a commercial shop in a four or five-year apprenticeship. Our experience has proven that this is really a very conservative estimate. And if they have already had a considerable amount of practical experience—as we hope many of the applicants will

have had, for many of them will be sons of foundrymen and others who have had opportunities to get this—then this practical training, added to what they already have, will be of an advanced character and will enable them to take up grades of work that would come entirely outside the range of the ordinary experience.

Second. Text book study, reading and recitations, practical talks and lectures: A great deal of this kind of information that I have tried to describe in the first part of my paper can be successfully and rapidly imparted through reading and study and by lectures and practical experiments and demonstrations given to a class of mature and earnest students by an experienced teacher. Our plan includes a systematic course of this kind extending all the way through each of the two years of the course.

Third. Drafting and designs: The third important subdivision of our course includes a variety of training given on the drawing-board. There are many problems that can be solved better with drawings than in any other way; and a foundry leader of the type that I am trying to describe must have facility with his lead pencil and ability to express his ideas on paper, to sketch the things that he wants done, and to design the details of foundry appliances and foundry equipment, if he is to get the best results. We are making provision for a thorough training along this line.

Fourth. Rapid and accurate computations of a great many kinds enter into the foundry business. These include not only estimating of costs and quantities of material but also a great variety of practical computations involving the use of formulas and more or less advanced mathematics. A systematic course of instruction is therefore planned involving computations of just this kind, including such branches of mathematics as are essential. Care, however, is taken to omit text-book subjects that do not find daily application in the foundry industry.

Fifth. The fifth principal subdivision of this new course of instruction is planned to cover all those principles of applied science which enter into the foundry industry, and those general principles of engineering such as steam generation, power trans-

mission, application of electricity and compressed air, strength and stiffness of materials, etc., which every foundry manager must understand if he is to become a leader of the type that we have been discussing today. We regard this feature of the course as extremely important and are giving a considerable amount of time to it. We have a special laboratory equipped for just this kind of work; and the students in the new course will be drilled, through lecture and recitation and through innumerable experiments in the laboratory, in all of these departments of applied science.

Sixth. Perhaps the most original part of the work, so far as school practice is concerned, is the instruction that has been planned in foundry chemistry and chemical and metallurgical engineering including, of course, the questions of combustion and the effects of temperature. The importance and value of this part of the work alone would require a special paper. We already have two laboratories especially devoted to this part of the work and are planning to fit up a third in order that we can give the students every opportunity to get just as complete and thorough training in this department of their profession as time will possibly permit.

Seventh. The time is too short for me to describe all the details, as they have been worked out, but there is one other point that I feel I ought to mention. All the way through my paper I have referred to the type of man for whom this course is planned as *"The Leader."* Leadership is a quality we certainly want to develop. It can be developed like any other quality, through practice, and therefore we have definitely planned to give the students in this new course opportunity to obtain systematic experience both in planning work and in directing the work of others. They will be expected to act as foremen supervising, first small operations, and as they gain experience, assuming larger and larger responsibilities.

Our experience in other courses has demonstrated that this kind of foremanship training does develop the quality of initiative, and qualities of resourcefulness, of courage and self-confidence which, taken together, we call leadership. And, therefore, we are planning to give in this course in Foundry

Management and Operation a considerable amount of attention to this all-important feature.

I am including a few selected photographs which will give you some idea of the facilities and the equipment which we have for carrying on this course. These, I think, are all self-explanatory and I am giving below the details of the course just as it has been announced in our new catalogue.

FIG. 12—ACCURATE CHEMICAL ANALYSIS IS THE KEY TO THE SOLUTION OF MANY DIFFICULT FOUNDRY PROBLEMS

OUTLINE OF COURSE OF STUDY

Two-Year Course in Foundry Management and Operation Intended for Persons Who Wish to Become Foundry Leaders.

—FIRST YEAR—

Applied Science.—Recitations and laboratory practice. The instruction in this course includes those principles of practical mechanics which have direct application in foundry practice. It also includes the study of the laws of heat and their application to the scientific melting of metals, baking of cores, etc.; the effect of high temperature of sands, facings, etc.; the laws of expansion and contraction of cast iron and the various alloys; the flow of fluids; the strength and stiffness of the several kinds of irons and alloys.

Theory Related to Foundry Practice and Foundry Chemistry.—The applied science instruction is supplemented by practical talks and lectures on the materials used in the foundry, the selection of

sands, facing-compounds, etc.; also on the different methods of making, venting, and drying molds and cores for various classes of work. These talks also cover cupola practice, grading and mixing of iron and of bronze and aluminum and of other alloys for different types of work.

Instruction is also given, both by recitations and by laboratory practice, in Foundry Chemistry and in making a great variety of practical commercial tests for determining the nature and quality of foundry materials and foundry products.

Blue Print Reading.—Brief instruction is given in blue print reading and in machine drafting for foundry practice in order that the student may understand and appreciate the relation of these subjects to the trades of molding and foundry practice.

Foundry Computations and Estimating.—The course includes sufficient practical arithmetic and use of formulas to train the student to make such computations and estimates as are needed in the foundry business.

Shop Practice.—The shop instruction includes bench and floor molding of patterns in great variety; experience with different kinds of molding sand and different kinds of facing; also open sand work, sweep molds, dry sand work, and instruction in machine molding; setting of cores, use of risers, and methods of gating and venting for unusual and difficult types of patterns. The course also includes instruction in architectural iron-work, stove-plate work, brass and aluminum casting, and the use of other alloys. There is also given instruction in core-making by hand and by machines; in pickling and other methods of commercially cleaning and finishing castings; and in lining, charging, and managing the cupola.

—SECOND YEAR—

Advanced Applied Science.—Recitations and laboratory practice. The instruction includes physical testing of foundry products and foundry materials; the strength, fineness, and permeability of molding sands and core sands; the measurement of high temperature and the effects of variation in temperature on foundry products and foundry materials; the study of combustion and air supply for furnaces; the principles and applications of compressed air and its use in foundry appliances; the applications of electricity to foundry work; the principles of strength of materials, and the strength, stiffness, toughness, and practical workability of various kinds of cast iron and steel and of alloys of different composition.

Advanced Foundry Chemistry, Sand Testing, and Cupola Management.—Recitations and laboratory practice. Instruction is given in methods of accurate qualitative and quantitative analysis of foundry materials, iron, and alloys; microscopic examination of sands, metal fractures, etc.; sand-testing by analysis, by microscopic examination, and by practical work in the foundry; and advanced instruction in cupola management and mixing metals.

Design of Foundry Equipment.—The instruction includes the planning and the detail design of a great variety of foundry appliances and foundry equipment.

Advanced Foundry Computations and Estimating.—This course is a continuation of the corresponding course given in the first year, and includes application of both algebra and plane geometry to problems in the foundry industry.

Advanced Shop Practice.—The shop instruction of the second year includes advanced work in practically all the lines included in the first year. More difficult and complicated types of work are undertaken and more time is devoted to dry sand molding, sweep molding, and heavy work handled with the travelling crane. Instruction is given in making matchboards and mounting patterns on molding machines for rapid reproduction.

In addition to the productive work in the shop, the student is placed in charge of certain departments of the shop at certain periods and is held responsible for the production. In this way he is given an opportunity to gain experience in laying out work and handling men.

Report on Fifth Annual Conservation Congress

Washington, D. C., Nov. 18-20, 1913.

By Paul Kreuzpointner, *Delegate.*

To the President and Members of the American Foundrymen's Association:—The American Foundrymen's Association having been requested by the United States Department of Commerce and Labor to be represented at the Fifth Annual Conservation Congress, to be held at Washington, D. C., your chairman of the Committee on Industrial Education was asked to act as the official delegate of the Association. Your chairman attended the Congress during its three days sessions and found the proceedings unusually interesting and instructive. The deliberations and the resolutions passed concerning the preservation of our remaining resources and of the question of Federal control of water power rights will prove to be of far reaching importance to our country.

Attention was called to the necessity of conserving our rapidly diminishing resources which, while still abundant as regards quantity, like coal and iron ore, are diminishing in quality which makes them more expensive because larger quantities are necessary to produce desired results. Thus, large quantities of Mesabi ore have to be washed at considerable expense and of the coal from 45 to 50 per cent is lost in mining. Of timber we are using 40 cubic feet per capita while the annual growth of our forests produces only 13 cubic feet per capita, or only one-third of the timber consumed is replaced by growth, hence, knowing the amount of available timber land it is a simple question of arithmetic to find out how many years our merchantable supply of timber will last and it was predicted at the Congress that in 33 years we would experience a scarcity of timber. While much has been done toward prevention of waste of timber and other of our resources, nevertheless, in order to secure a more rational and

economic use of these resources, without depriving the present generation of their uses to secure our comfort it is highly desirable to diffuse the knowledge of how and why it is necessary to conserve our resources, through the homes, schools and workshops as widely and persistently as is possible.

Shops, factories and industrial schools are the easiest agencies through which to train habits of economy of resources through the manipulations of the daily work and in the industrial school by co-ordinating the teaching of technical knowledge with the reasons how and why to use our mental material and physical resources for the immediate and future benefit of oneself and of the community of which we are a member.

A large part of the time of the Conservation Congress was devoted to the discussion of the Federal control of water power rights.

The idea was and is being held by some that conservation meant reservation of our resources, including water power, by the federal government for their utilization by future generations while depriving the present generation of the benefits of their uses. This sentiment was expressed very strongly during the discussion on Federal control of water power rights. The friends and defenders of Federal control claimed that conservation did not mean reservation and the locking up of our resources but that proper utilization meant conservation, and since there cannot be proper utilization, that is, rational economic consumption, without conservation, the Federal policy of conservation means nothing more nor less than properly regulated utilization of national resources. Three reports on water power were presented to the Congress, forming the occasion for heated discussions for a day and a half between the friends of Federal control and the defenders of state control.

In stating the principles of conservation it was pointed out that conservation was concerned with three kinds of natural resources:

1.—Resources which are not renewable and in which utilization destroys their uses for all time. Among these are coal, oil, gas, ores, minerals, phosphates, etc.

2.—Resources which are self-renewing although at a slow rate, like forests. While in their case utilization diminishes the available amount of the resources, future generations may be able to replace the loss.

3.—Water power is a resource which is different in its nature from the other two inasmuch as the other two, if not utilized, are preserved while water power, if not utilized, goes to waste, without benefit to anybody.

Hence, while in the case of the other non-renewable resources economy and restriction should be the governing principle of their uses, in the case of water power, utilization to the fullest extent should be the rule. But the development of water power is expensive and hazardous and therefore the rights of development of water power must be guaranteed for long periods with a comparatively safe profit. It was stated that we use 480,000,000 of tons of coal annually, beside large quantities of other fuel, worth a billion dollars, and $200,000,000 worth of fuel might be saved annually if our water power were developed. The unanimous report of the Committee on water power recommended the granting of the right to the use of water power under similar conditions as other rights and franchises are granted by the Government.

A minority report was also presented. This minority report recommended, in addition to the rights and privileges granted by the government for the utilization of water power, that a certain amount, or percentage, of the profit should be paid to the Government during the life of the privilege. It was claimed that ten groups of interests now control 65 per cent. of the available water power, equal to 6,270,000 horsepower and Federal control with a fair profit guaranteed to those who developed the water power with a moderate profit paid to the Government, would prevent concentration of water power in the hands of a few of those who might intend to hold the privilege without developing it. The minority report added certain stipulations to the majority report both of which then, the majority and minority reports, represented a division of opinion between the members of the committee who, at first, had agreed upon the unanimous report.

The discussion on the acceptance of the one or the other of these reports developed into a prolonged and heated argument between the advocates of Government rights and Federal control of water power and the advocates of state rights and state control of water power. A motion to refer all three reports to the committee on resolutions was lost by a vote of 434 against by the friends of Federal control, to 154 votes for the motion by the friends of state control.

When the report of the Committee on Resolutions was presented to the convention, Gifford Pinchot offered an amendment and this amendment was amended by Congressman Burnett. This amendment to the amendment was voted down with 378 votes by the friends of Federal control against 132 votes cast by the defenders of state rights. The amendment by Mr. Pinchot was then finally voted on with 317 1-3 votes for the amendment by the friends of Federal control against 96 2-3 votes by the friends of state rights, the vote being taken by states. This late vote virtually adopted the minority report of the Water Power Committee. The minority report, in its recommendations, claims to prevent the monopolization of water power in the hands of a few private owners.

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